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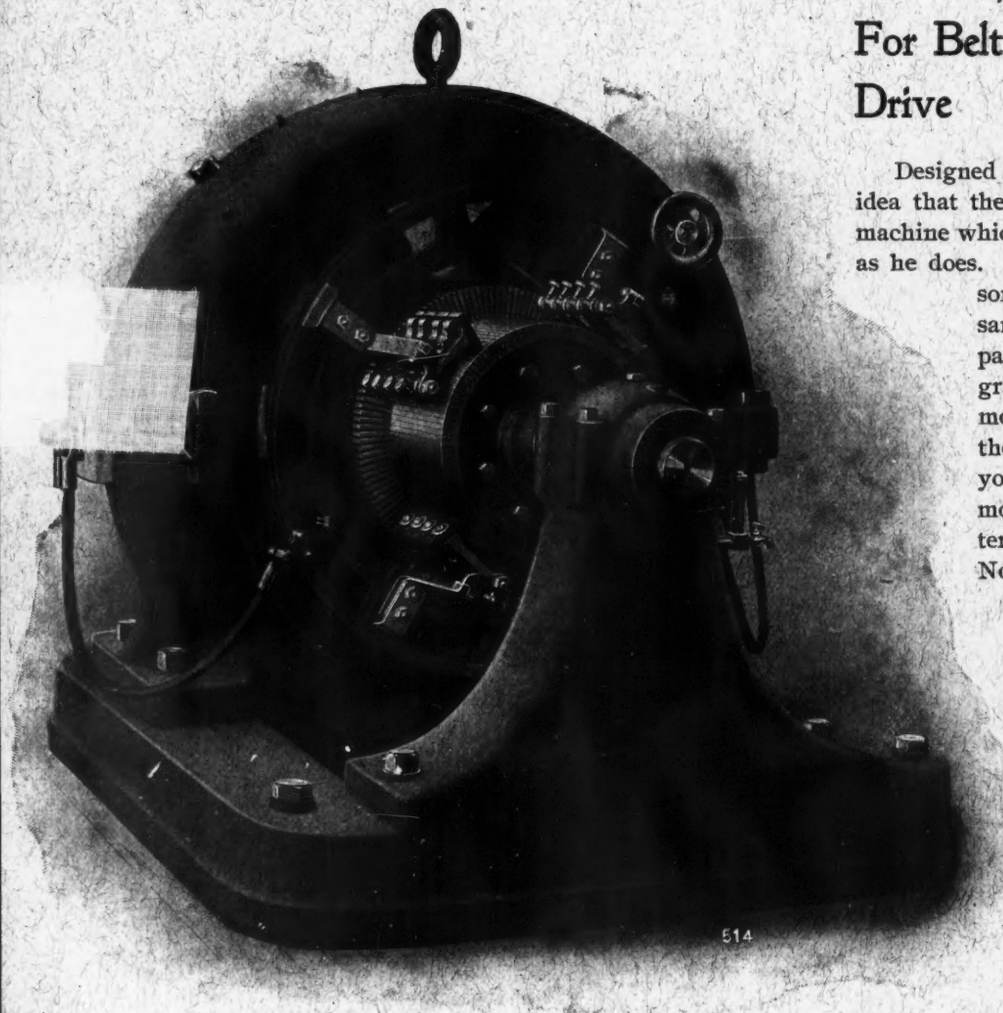


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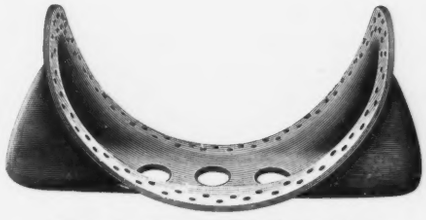

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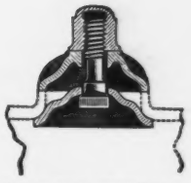

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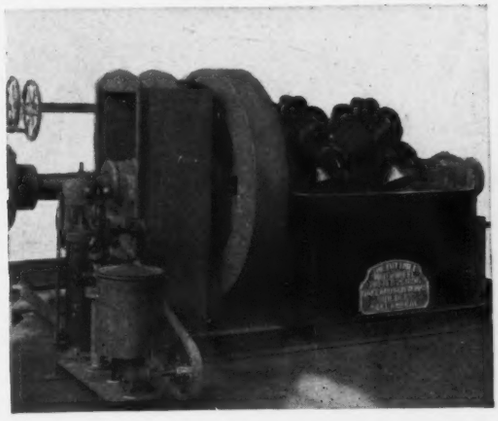

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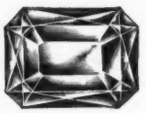
TRADE  MARK

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## ADVERTISERS' INDEX.


| | PAGE |
|---|---|
| Akron Smoking Pipe Co | ix |
| Allen, Wyatt H | v |
| American Circular Loom Co | ix |
| American Electric and Automobile Patents Monthly | vi |
| Benjamin, Edward H | v |
| Bossert Electric Construction Co., The | ix |
| Byron Jackson Machine Works | vii |
| California Electrical Works | vii |
| California Incandescent Lamp Co | xiii |
| Carter, & Co., George E | iii |
| Century Electric Co | v |
| Cobb, Edward S | v |
| Cole, John R | ix |
| Cory, C. L | v |
| Crosscup, I. O | vii |
| Crouse-Hinds Electric Co | xv |
| Cutter Co., The | ix |
| Dearborn Drug and Chemical Works | xii |
| Doble, Robert McF | v |
| Dow, Geo. E., Pumping Engine Company | x |
| Electric Storage Battery Co | iii |
| Fry, Donald H | v |
| General Electric Company | i |
| Half Tone Co., The | vi |
| Hall, Leon M | v |
| Hardwood Planing Mill Co | i |
| Heald's School of Engineering | vi |
| Hunt, A. M | v |
| International Correspondence Schools | xiv |
| Joseph Dixon Crucible Co | i |
| Knight & Co | vi |
| Knowles, C. S | iv |
| Locke, Fred M | vii |
| Lombard Governor Co | xi |
| Martin & Co., Jno | vii, viii, x, xvi |
| Masson, R. S | v |
| Mead Cycle Co | xiv |
| Medina, Frank P | v |
| Meredith, Wynn | v |
| Moore & Co., Chas. C | iii |
| National Conduit and Cable Co | ix |
| National Tube Company | iv |
| New York Insulated Wire Co., The | ix |
| Northern Electrical Mfg. Co | ii |
| Oakland Iron Works | iii |
| Okonite Company, Ltd., The | i |
| Pacific Electrical Works | xiii |
| Paraffine Paint Company, The | vii |
| Partridge, John | vi |
| Pass & Seymour | xv |
| Pelton Water Wheel Company | xii |
| Pittsburgh Reduction Company | viii |
| Ridley, A. E. Brooke | xii |
| Risdon Iron Works | xi |
| Roebling's Sons Co, John A | iv |
| Santa Fe Railway Company | xiv |
| Sloane Company, The Chas. F | xii, xv |
| Smith, F. E | v |
| Smith, W. Stuart | v |
| Southern Pacific Railroad Company | xiv |
| Stanley Electric Manufacturing Co. | xiii |
| Stanley Instrument Co | vi |
| Turner, C. L | v |
| Union Lumber Company | iii |
| Van der Naillen School of Electricity | vi |
| Van Emon Engineering Company | xii |
| Wagner-Bullock Electric Co | v |
| Westinghouse Electric & Manufacturing Co | viii |
| Weston Electrical Instrument Co | i |
| Worthington, Henry R | x |



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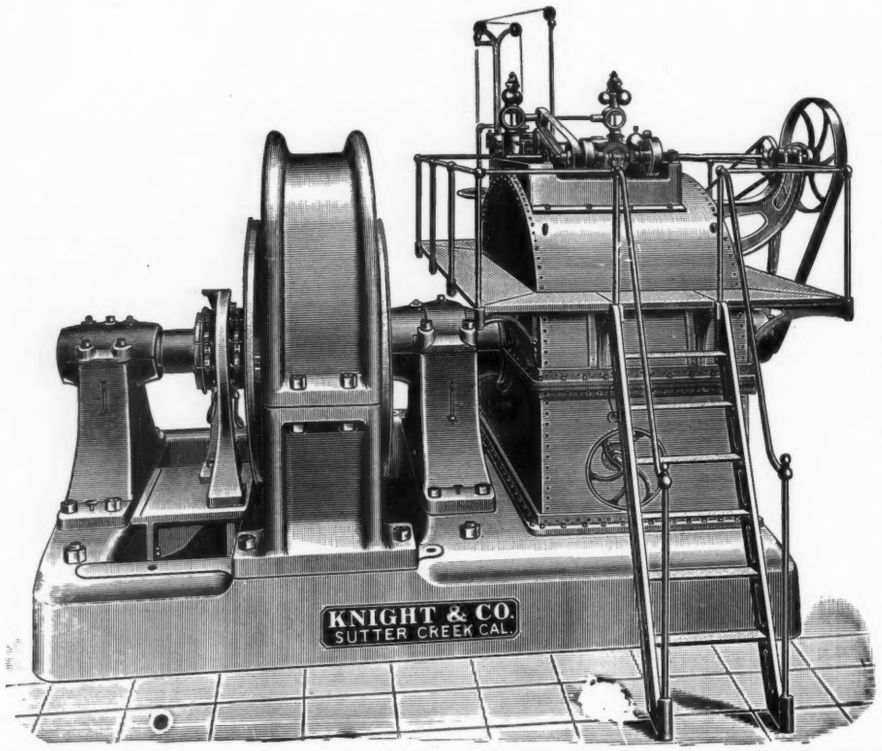


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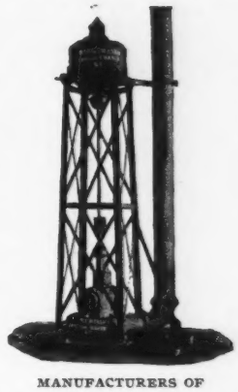

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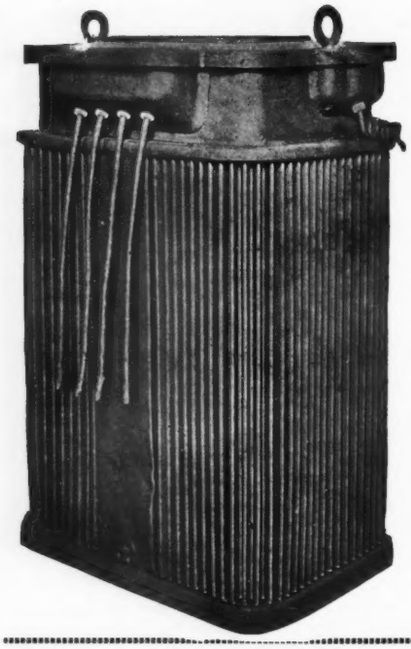

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Devoted to the Conversion, Transmission and Distribution of Energy.

VOLUME XII. SAN FRANCISCO, AUGUST, 1902. NUMBER 8

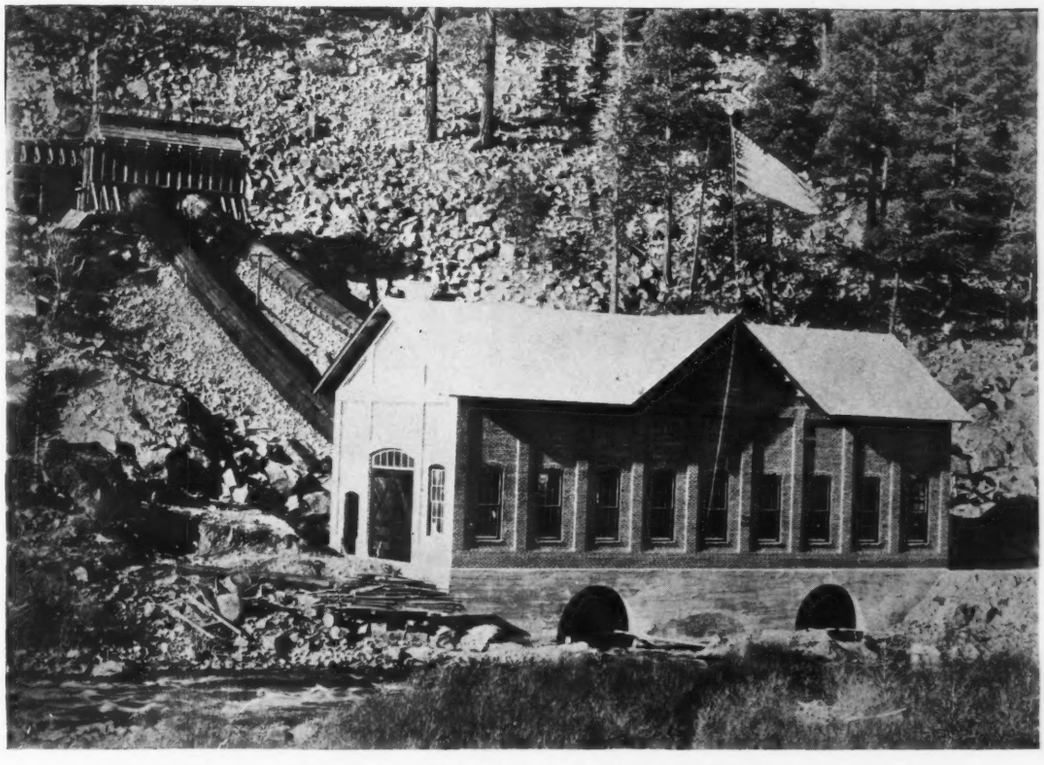

## *Recent Application of Electrical Power on the Comstock Lode.**

*BY LEON M. HALL.*

So much has already been said and written about the Comstock, its resources and its machinery, that it is a difficult task to place an entirely new theme before you; however, I will endeavor to take up the most important features of our new installation and trust that they may be of interest.

About two years ago the agitation for electric power and modern methods on the Comstock culminated in the incorporation of the Truckee River General Electric Company, the subsequent successful installation of a power plant on the Truckee River and in the use of electrical energy in the mining operations on the "Old Lode."

Briefly, the force transmitted to and used by the mining companies on the Comstock Lode is generated by the waters of the Truckee River, about two miles east of Floriston. At a point just below the plant of the Floriston Pulp and Paper Company, a crib dam is thrown across the river and this serves to divert the stream into a ditch, or rather an open channel, about 600 feet long; from thence to a point directly above the generating station, the water is carried 8600 feet in a wooden flume 6 feet 8 inches high and 10 feet wide. Head gates are placed in the side of this flume and two redwood stave pipes 6 feet in diameter and 160 feet long are used to take the water from these gates to the wheel casings. Two pair of 27-inch horizontal McCormick turbines are directly connected to two 750-kilowatt Westinghouse three-phase generators of the revolving armature type. Each pair of wheels will develop about 1400 horsepower at 400 revolutions per minute under a head of 84½ feet. Two type "B" Lombard governors are used to secure the necessary regulation in speed. The 750-kilowatt machines generate at a potential of 500 volts and they are separately excited by two 22½-kilowatt direct current exciter units. These exciters are driven by small



PENSTOCK, PIPE LINE AND POWER HOUSE OF THE TRUCKEE-COMSTOCK TRANSMISSION.

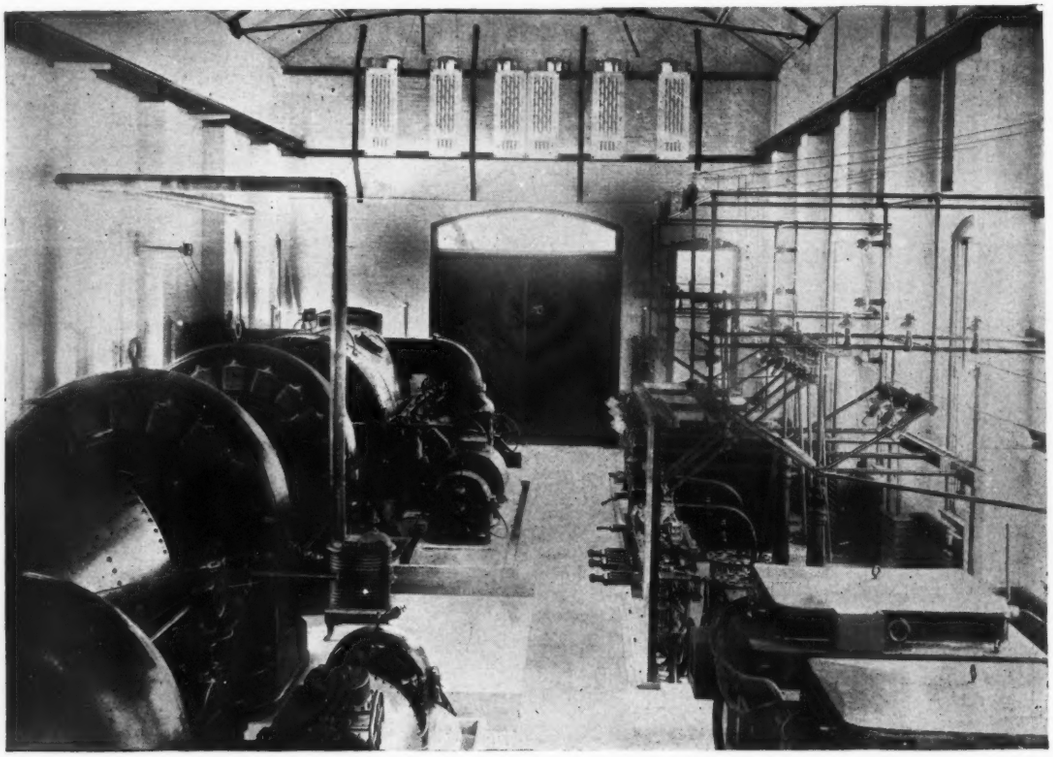
*A paper presented to the Sixth Annual Convention of the Pacific Coast Electric Transmission Association, June 17-18, 1902.

McCormick turbines which take their water supply from the 27-inch wheel casings.

The generating potential of 500 volts is raised to 24,000 volts by means of two sets of 300-kilowatt Westinghouse oil insulated transformers located in the power-house. At this potential the current is transmitted about 35 miles to the sub-station at Virginia City, over a double circuit of No. 4 hard-drawn copper wire. On the line, square redwood poles 30 feet in length, pine cross-arms, locust pins and 7½-inch Locke insulators are used On these same poles the telephone circuit is carried by means of oak brackets and pony insulators. At the sub-station the potential is lowered to about 2300 volts by means of two sets of 250-kilowatt Westinghouse oil insulated transformers. At this voltage the current is distributed to the works of the various mining companies. The distribution circuits are of weather-proof wire and are calculated for a 4 per cent. drop under full load. The power house is a substantial brick structure on a concrete foundation and is roofed with galvanized iron upon iron roof trusses. The sub-station is covered entirely with corrugated galvanized iron. This plant was first started on September 29, 1900, and has been running continuously since October 20th of the same year. The service and regulation is good, in fact, with the exception of a few stoppages, due to severe storms, the service has been very free from interruptions.

The mining companies purchase power of the Truckee River General Electric Company at $7.00 per horse-power per month; the amount used being based upon a peak load to two minutes' duration when electrical hoists are operated directly upon the lines. Ordinarily this condition is a rather severe one, from the consumer's standpoint, and this, among others of which I will speak later, has necessitated the installation of machinery which is rather unique in character, and of the very highest grade, as will be observed from the descriptions to follow. Throughout the entire work at the mines nothing but the best quality of material has been used and every precaution taken to secure thorough reliability and the highest efficiency possible under existing conditions.

On the Comstock Lode proper, and directly under my supervision, there are twelve separate installations with an aggregate of about 1200 horsepower in motor capacity; this will soon be increased to about 2000 horse-power by the installation of electric pumps and fans.



GENERAL VIEW OF THE INTERIOR OF THE POWER HOUSE.

My first aim in laying out these plants was to standardize the motors, transformers and material to as great an extent as possible and also to keep the same character of machinery at each mine. The result has been that all motors of 50 horsepower and over are operated directly upon the distribution circuits at 2240 volts, excepting the General Electric variable speed induction motors on the electric hoists. The latter and all of the smaller motors are 440-volt three phase machines. All of the power transformers are, therefore, 2240-440-volt transformers and are connected in delta. The lighting circuits, with one exception, a 220-volt three wire system in the Gould and Curry tunnel, are all 110 volts. Both enclosed arcs and incandescents are used without difficulty at this voltage.

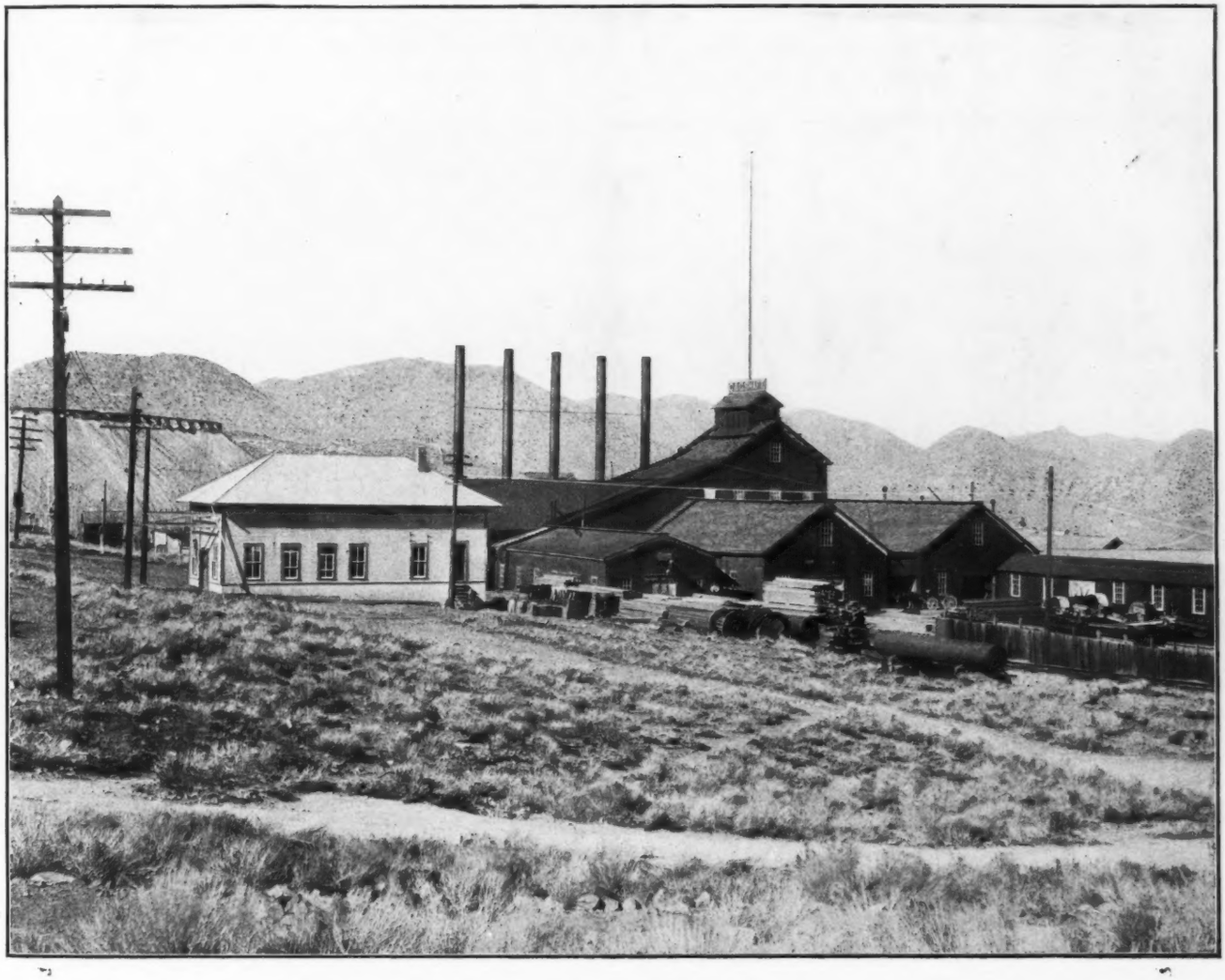
This arrangement has proven of value in many ways, among which may be mentioned the facility with which the motors are moved from place to place underground, also enabling us to run the wires from one property into another without any change in the wiring or machinery.

Every conceivable use has been made of the electric motor for mining purposes, with the possible exception of the operation of rock drills therewith, and now that they are in vogue, it is a difficult matter to imagine how the Comstock mines got along without them. The motors driving ventilating fans have superseded the compressed air engine and have also enabled us to work in ground that was formerly so excessively hot as to preclude such a possibility. The capacity of the sawmills has been doubled since the motors were put in, the air compressors are now all belt driven, the electric hoists are a marked success and the new electrical pumping plant, for the C. & C. shaft, now under construction by the Allis-Chalmers and Westinghouse Companies, will certainly be the largest and best of its kind.

The distribution of electric power along the different lines of machinery is as follows: 25 horsepower on machine tools, 75 horsepower on fans, 150 horsepower on sawmills, 185 horsepower on batteries and concentrators, 225 horsepower on air compressors, 500 horsepower on hoists, 675 horsepower on the electric pumps and about 60 horsepower on the lighting circuits, exclusive of the city lights.

The wiring has been divided into power circuits, lighting circuits and the telephone circuits.

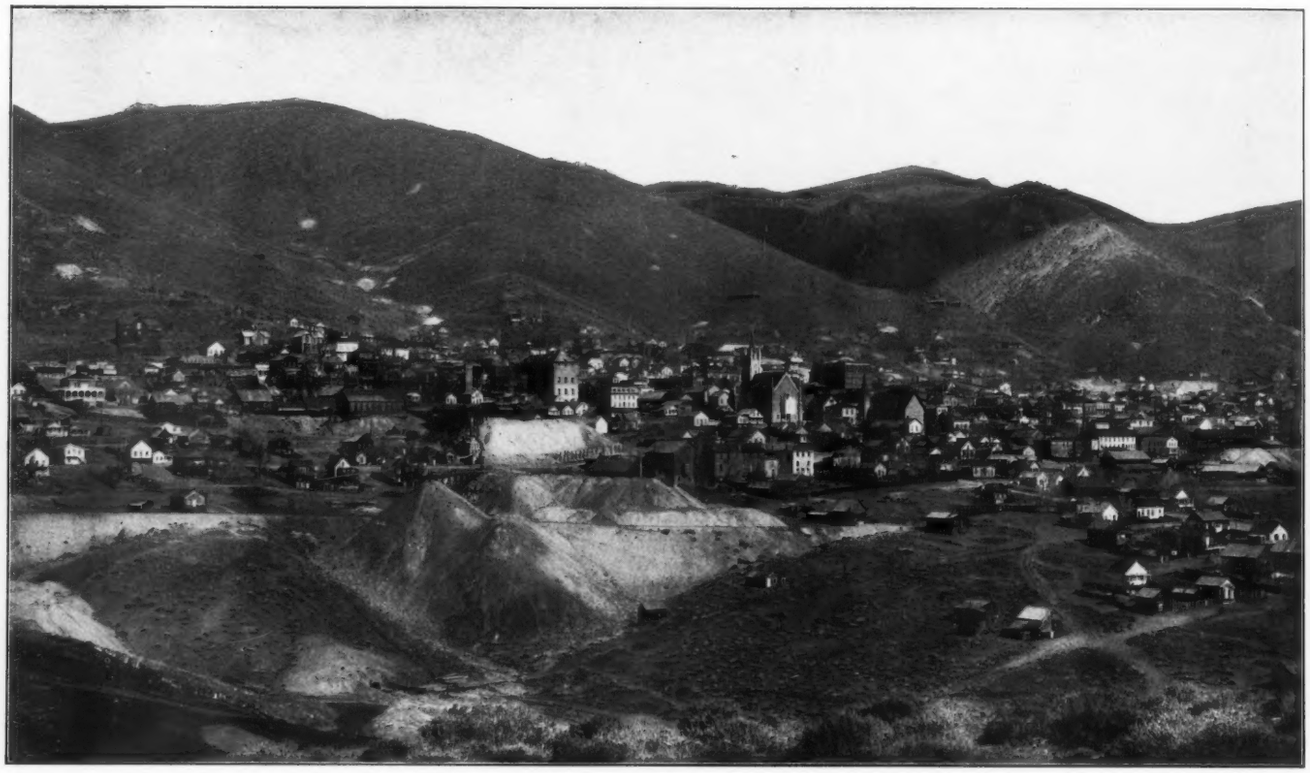
Excepting upon the exterior overhead construction and in the shafts, the best quality of rubber-covered copper wire has been used. The power and lighting circuits, both in the buildings and in the underground workings, are placed on glass insulators whenever the potential exceeds 500, and in all other cases porcelain knobs and cleats are used. Lead-covered cable is sometimes placed in very wet sections underground, and extension cords made of flexible rubber-covered wire are used to take the lights from any specified point into the slopes and working faces. These cords are easily removed before each blast and replaced immediately thereafter. A two-wire rubber-covered telephone cable is taken down the C. & C. shaft on No. 3 porcelain knobs



C. & C. SHAFT AND SUBSTATION.

and a telephone placed at each station. This telephone system has proven invaluable.

At the point where the 2240-volt lines enter the buildings a bank of lightning arresters is located and these are immediately followed by three single pole quick break switches; the latter enable us to free our lines in case of fire or accident to the mine circuits From these switches the lines are carried directly to the transformers, motors or shaft cables. In addition, each installation is equipped with a Westinghouse integrating wattmeter and its transformers. The power and lighting transformers are all properly fused and in every case I have insisted upon fuses in the motor circuits. Experience has taught us that oil break switches are the

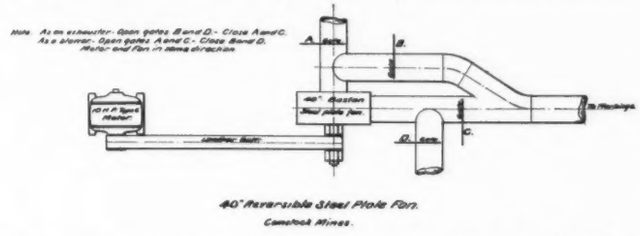


VIRGINIA CITY FROM THE EAST.

only thing to use on the 2240-volt motor circuits and cables, in fact, we have now so equipped all of our machines excepting the smaller Westinghouse type C motors; these have a triple pole quick break switch in addition to the usual auto-starting device. Triple conductor lead-covered cables, armoured with galvanized iron wire, are used in the shafts and the current taken into the mine at a potential of 2300 volts. This potential is lowered in the mine as near as possible to the point of consumption. There are two of these cables in the C. & C. shaft, one with three No. 6 stranded copper wires for lighting and fan circuits and the other with three No. 1/0 stranded copper wires for transmitting power from the surface to the pump motors on the 2150-foot level. At the head of each cable is placed an oil break switch and a set of expulsion fuse blocks. At each intersection with the cable an air-tight, cast-iron junction box is located and the lead cable covering sweated into tight-fitting sleeves located in the sides of the box. These cables were manufactured by the General Electric Company and were tested to 4000 volts at the factory. Owing to their great weight, (i. e., six and ten tons, respectively), much care was necessary to properly install them. The cable was lashed at intervals to the six-inch hoisting rope as it was being lowered down the shaft; when the bottom was reached we began at the surface and clamped the cable to the wall plates, as shown on the accompanying diagram marked A. These clamps were placed about 50 feet apart and the intervening stretches secured by means of the ordinary plumbers' staples driven into the shaft timbers. One of these cables has been in use for more than a year and the creeping up to this time has been barely perceptible.

For many years the proposition of ventilation has been an important one to the Comstock mines and has received much serious consideration. In all mines fresh air is a necessity—in our mines, owing to the excessive heat and steam from the hot water, it is the very life of the employees. Years ago the companies used Root and Baker blowers, extensively, to force air into the mine from the surface. These have disappeared entirely and more attention has been given to natural means of ventilation by connecting the various shafts on the different levels. It then becomes a much simpler task to force the air into the workings from various cool places in the mine. Formerly small compressed air engines were

used to drive the fans, but much trouble was experienced in keeping these up to speed, so they were among the first machines to be superseded by the electric motor.

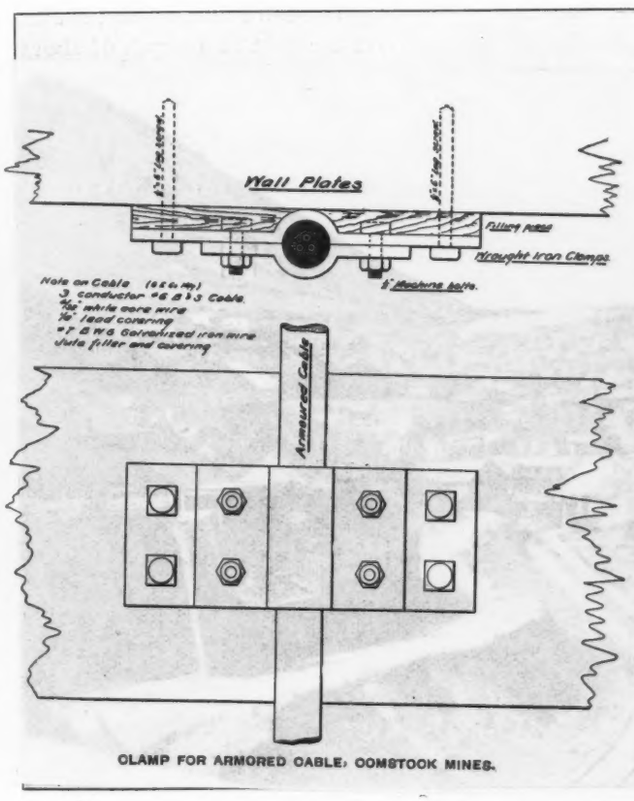


40" Reversible Steel Plate Fan. Comstock Mines.

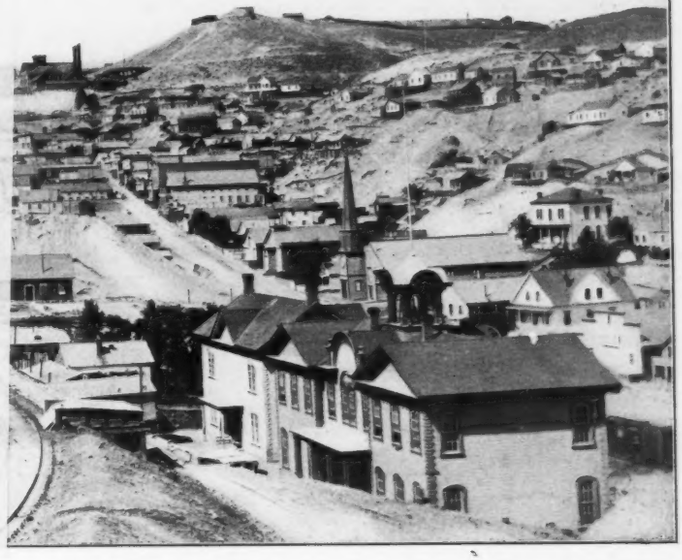
At the C. & C. shaft six-foot fans with a wooden housing are in use and to these are belted 10 and 15-horsepower type C motors. As an illustration of this character of a blower, kindly refer to the accompanying photograph of a fan on 2150-foot level. In the Hale and Norcross tunnel, a 40-inch steel plate exhaust fan is driven by a 15-horsepower type C motor and it is so arranged that it may be used either as an exhauster or a blower. This arrangement is shown on the sketch marked B. This contrivance is exhausting 2000 feet through a 15-inch air pipe while running 1500 revolutions per minute and is doing excellent work. Direct connected fans are used, but it is a difficult matter to make the motor speed fit that of the fan without unduly increasing the size of the runner and still maintain sufficient velocity to drive the air long distances.

The sawmills usually consist of a 48-inch crosscut saw and a 36-inch rip saw. A 30-horsepower induction motor is belted to them and they are used for all kinds of sawing and for timber framing.

At the present time we have but one mill in operation by electric power, namely, the Best and Belcher mill. This plant is equipped with a Gates crusher,nine Kinkead mills,nine six-foot and four four-foot Frue vanners, a canvas plant, plates, sizer, conveyers, etc. The crusher and mills are driven by three 20-horsepower induction motors and the vanners by three 5-horsepower motors. The mill has a capacity of about 100 tons daily and is now doing excellent work on $6.50 ore. No difficulty has been experienced in the mill with speed regulation, although there are seven electric hoists on the same circuit.

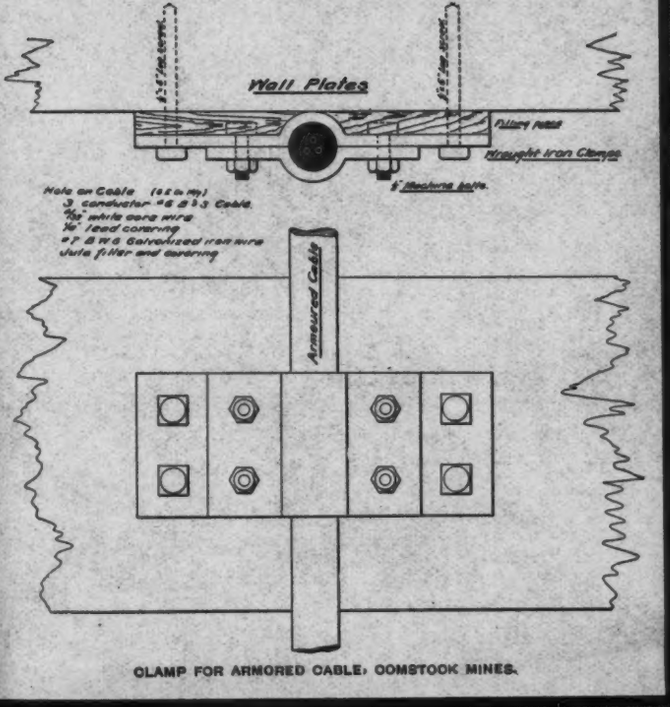



CLAMP FOR ARMORED CABLE, COMSTOCK MINES.



GOLD HILL FROM THE SOUTH.

In the majority of cases the old single stage engine driven air compressors have been converted into belt driven machines and are doing fair work, although the constant speed is rather severe on the old machines. At the C. & C. shaft a 16½x30-inch Rand and Waring compressor is belted to a 100-horsepower type C motor and operates at 73 revolutions per minute. The necessary reduction in speed is obtained by use of a counter shaft and wooden rim pulleys. No regulator is used, as the air compressor is at its maximum capacity the greater portion of the time. It is started light and this is accomplished by the use of a simple relief valve in the discharge pipe. At the Yellow Jacket a 9-in 14-in. by 15-in. duplex tandem compound Rix air compressor is belted to a 75-horsepower General Electric induction mo-

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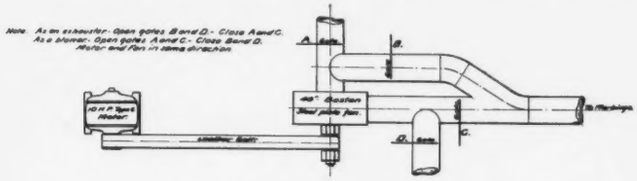

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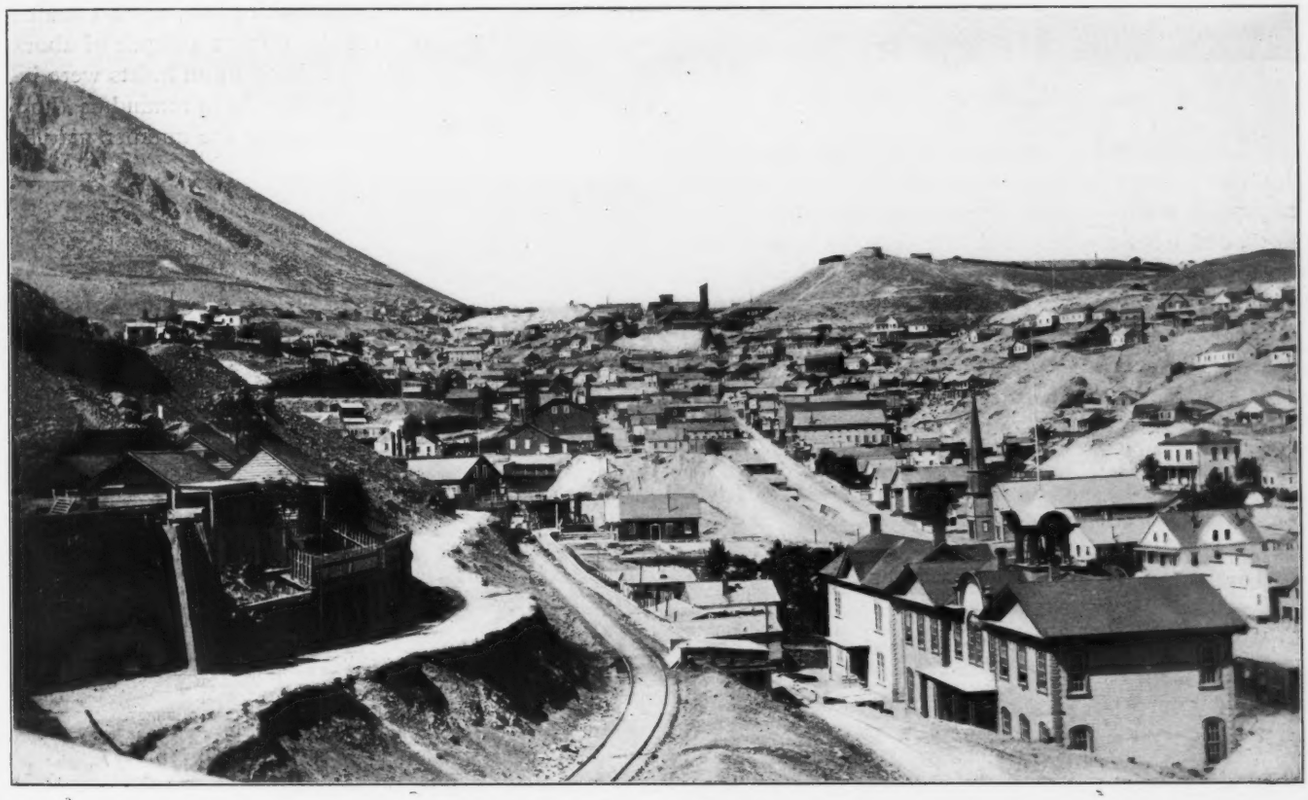

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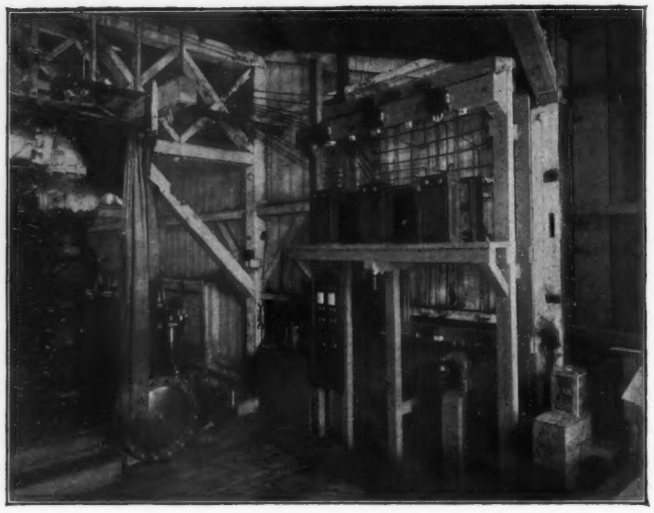


TRANSFORMER RACK AND METER AT C. & C. SHAFT.

tor. This machine is operated at 104 revolutions per minute under a pressure of 90 pounds to the square inch. This speed is rather high for a machine with spring valves, and I believe that such compressors should have mechanically operated valves and should be arranged as a variable volume machine with automatic regulation.

Probably the most unsatisfactory problem with which I had to deal was the equipment of the various shafts with a hoisting plant which would be economical and reliable without being detrimental to the transmission system at large. This has been accomplished in a most satisfactory manner by the adoption and installation of variable speed induction motors, and in the majority of cases, the balanced or tail rope system of hoisting.

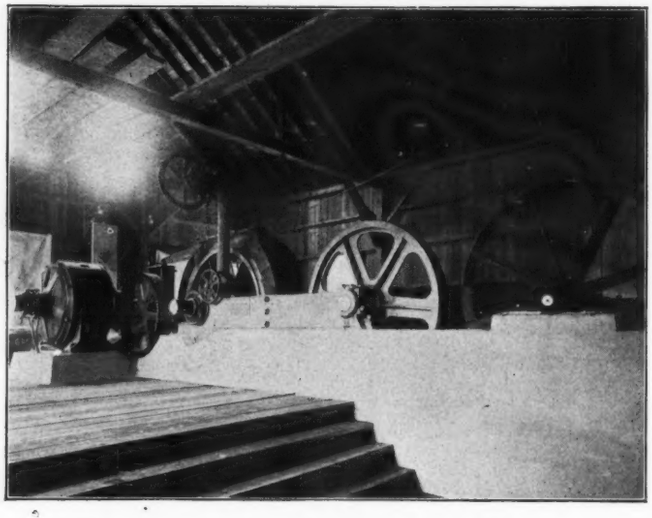
It is a matter of history that the Comstock engineers were pioneers in the design of deep mine hoisting machinery and upon the Lode to-day may be traced the product of their brain from the earliest V friction drums with a hemp rope to the massive direct acting hoists of the present day. The machinery on the first line of

100 HORSEPOWER INDUCTION MOTOR DRIVING AIR COMPRESSOR AT C. & C. SHAFT.

mentioned the 26 by 72-inch double engine which raised nearly six million dollars in one month from the 1650-foot level of the C. & C. shaft. The 32 by 96-inch first motion hoist which was used at the Union shaft is now doing good service on the Parrott Mine at Butte, Montana. With this class of machinery a rope speed of 3500 feet per minute with a load of 10 tons was not an unusual occurrence. The cost of operation was, however, enormous, and as the resources diminished they were gradually abandoned and will soon all give way to the regime of electricity.

In the selection and design of our new hoisting machinery it became necessary to look carefully into existing conditions, the service required, and finally the probable effect upon the transmission system as a whole. The cost of power (i. e., $7.00 per horsepower per month on a peak load basis) was a factor not to be overlooked and necessitated the highest efficiency possible. At first it was thought that the old steam plants could be operated with compressed air obtained from motor driven air compressors. This was tried and abandoned on account of the marked inefficiency obtained. Secondly, it was suggested that the motors could be geared directly to the existing flat rope reels. The motors in this case would have been very large and this was abandoned on account of the excessive bills for power incident thereto. The latter is also applicable to new motor driven drum hoists and we finally adopted the balanced system and variable speed induction motors, with a resulting efficiency that has not been approached on this Coast.

The first electric hoist we had in operation was at the shafts, near the outcrop, was of the most primitive character. The second line, which cut the vein at about 1200 feet, was equipped with geared hoists, single engines and flat rope reels. The third line, or east shafts, were designed to intersect the vein at a depth of about 300 feet, and the best class of first motion hoists were installed. Of the latter but few remain to remind us "how the mighty have fallen," and among the number may be



200 HORSEPOWER ELECTRIC HOIST AT C. & C. SHAFT.

Sierra Nevada and was a 20-horsepower type F Westinghouse motor geared directly to a double drum steam hoist. The engine connecting rod was dropped when the motor was put on and the remainder of the machine left just as it was. This has given good service for about a year and a half, but, as is usual in the case of poorly designed rigs of this character, it does not operate as perfectly as it should. With this small rig, as shown in the photographs, we are raising 2000 pounds at about 300 feet per minute from a depth of 350 feet.

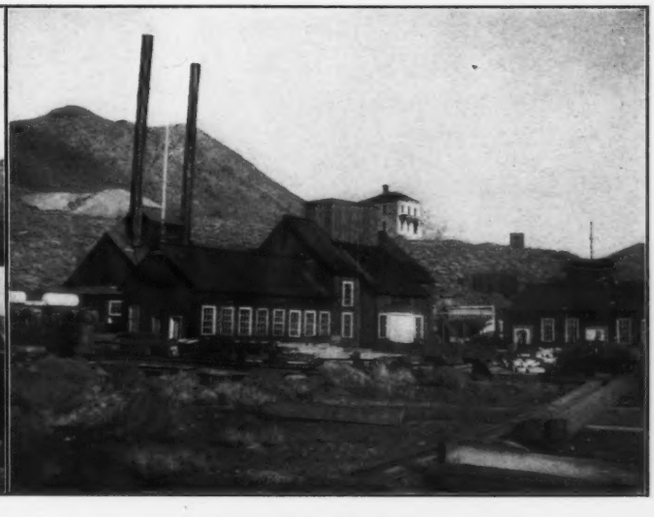
Within the past few months two other small electric hoists, with friction clutches on the drums, have been erected, and they are also giving satisfaction. One of these, a 15 horsepower, is operated under ground at the Silver Hill Mine.

To meet the condition of high efficiency it is self evident that the hoist and motor must operate continuously at or near their full load capacity and be designed especially for the work they have to perform. For a continuous full load condition the machinery must be just large enough for its maximum duty and the work must of necessity be constant at all points in the lift. The nearest possible approach to this was secured by the adoption of the continuous rope or balanced system, wherein the load is reduced to the weight of the rock alone. Then to secure the necessary variations in speed an induction motor with a non-inductive resistance in both primary and secondary was developed—the resistance being varied by the introduction of a special controller similar in appearance to that on the ordinary street car. With an equipment of this kind the cages are under perfect control and the speed varied to suit all conditions of service.

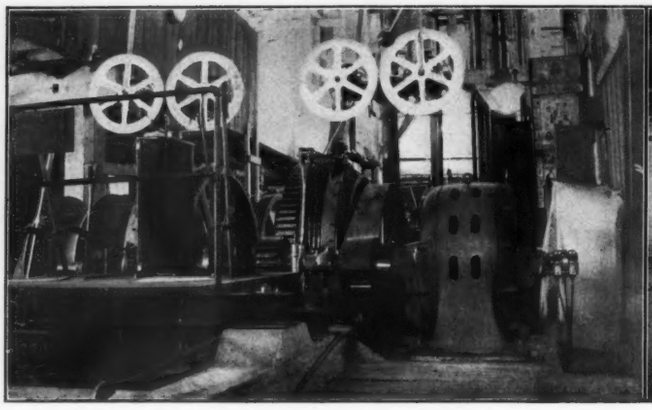
The hoist itself, as will be observed in the accompanying photographs, consists of a main driving drum and an idler, around which the rope is wound four times in order to secure the necessary friction for lifting. From the main driving drum the rope goes over the head sheave, down one compartment, under a movable tail sheave, back to the second compartment, over a second head sheave and to the driving drum. One cage is inserted between the ends of the cable and the other is fastened to the rope with heavy iron clamps. This simple arrangement permits of a variation in the relative position of the two cages and allows us to use a single cage in one compartment without reference to the other. The hoist is a geared machine, the motor speed being reduced by the use of cut gearing. To the main drum is attached a brake ring upon which a heavy port brake is operated. This brake is set automatically by means of a weight and is released by hydraulic pressure. In the case of the Yellow Jacket and Belcher there are two hoists side by side, both being operated by a single motor. One of each is intended for the vertical shaft and the other for the incline, which leaves the vertical at the point where intersected by the vein. The hoists are designed for double deck cages in each compartment of the vertical shafts and for two-ton self-dumping giraffs in the inclines. The machinery is all erected in a most substantial manner upon concrete foundations and this has resulted in practically no vibration and very little noise.

FAN AND MOTOR, 2150 FOOT LEVEL, C. & C. SHAFT.

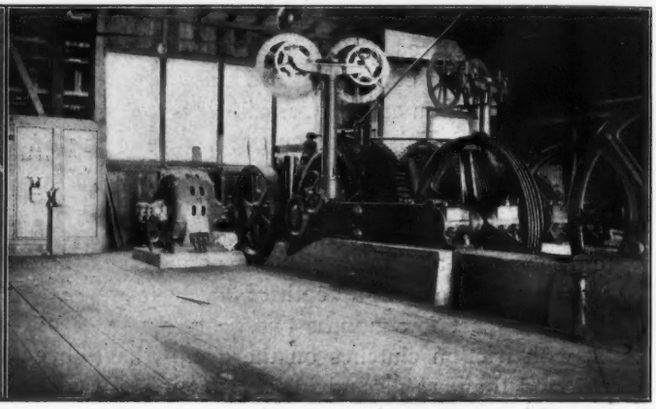
THE YELLOW JACKET.



THE BELCHER.



THE YELLOW JACKET HOIST.

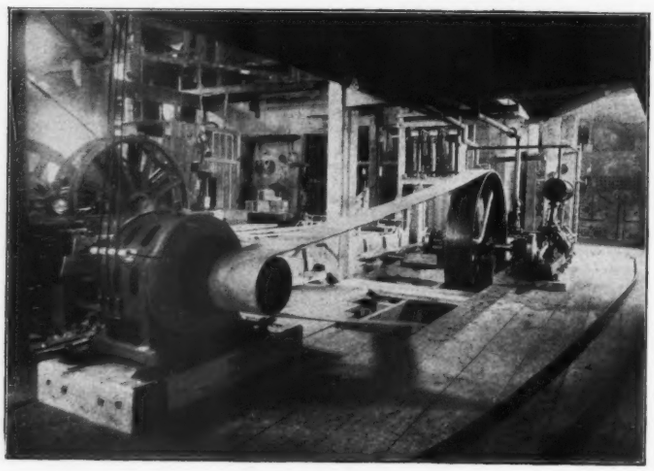


THE BELCHER HOIST.

The following table gives complete data upon each of the four installations:

| KIND OF HOIST. | Yellow Jacket G. & S. Mg. Co. | Belcher Silver Mg. Co. | Union Shaft Co. | Con Cal. & Vir. Mg. Co. |
|---|---|---|---|---|
| | Double continuous Rope Hoist for 4 Compartments. | | Single Continuous Rope Hoist for 2 Compartments. | |
| Daily capacity from bottom | 500 tons | 500 tons | 500 tons | 600 tons |
| Make of motor | Gen. Elect. | Gen. Elect. | Gen. Elect. | Westinghouse |
| Type of motor | M 7200 alternations | M 7200 alternations | M 7200 alternations | F 7200 alternations |
| Electromotive force | 440 volts | 440 volts | 440 volts | 2240 volts |
| Size of motor | 75 H. P. | 75 H. P. | 100 H. P. | 200 H. P. |
| Speed of motor | 450 R. P. M. | 450 R. P. M. | 450 R. P. M. | 550 R. P. M |
| Weight of rock | 3200 lbs. | 3200 lbs. | 3200 lbs. | 3760 lbs. |
| " double-deck cage | 2200 lbs. | 2200 lbs. | 2100 lbs. | 3951 lbs. |
| " two cars (max.) | 1700 lbs. | 1700 lbs. | 1700 lbs. | 1730 lbs. |
| " rope in each shaft | 1896 lbs. | 1390 lbs. | 2528 lbs. | 5000 lbs. |
| " total load raised | 8996 lbs. | 8490 lbs. | 9528 lbs. | 13,441 lbs. |
| " unbalanced load | 3200 lbs. | 3200 lbs. | 3200 lbs. | 3760 lbs. |
| Diameter plow steel rope used | 1 in. | 1 in. | 1 in. | 1 1-8 in. |
| Weight of rope per foot | 1 58 lbs. | 1.58 lbs. | 1.58 lbs. | 2 lbs. |
| Distance load to be hoisted | 1175 ft. | 850 ft. | 1558 ft. | 2500 ft. |
| Max. rope speed per minute | 600 ft. | 600 ft. | 750 ft. | 1250 ft. |
| Weight of incline car | 2000 lbs. | 2000 lbs. | ..... | ..... |
| Weight of rock | 4000 lbs. | 4000 lbs. | ..... | ..... |
| Length of incline rope from sheave | 1500 ft. | 1350 lbs. | ..... | ..... |
| Size of incline rope | 1 in. | 1 in. | No inclines | No inclines. |
| Length of incline | 400 ft. | 550 ft. | ..... | ..... |
| Size of each compartment | 5 ft. x 7 ft. | 5 ft. x 7 ft. | ..... | ..... |
| Unbalanced load on incline | 4000 lbs. | 4000 lbs. | ..... | ..... |
| Max. rope speed per minute | 600 ft. | 600 ft. | ..... | ..... |
| Angle of inclination | 45 deg. | 36 deg. | ..... | ..... |

Hence it will be seen that by the adoption of the aforesaid machinery we have approached very closely to the ideal, inasmuch as the actual load lifted is the weight of the rock alone plus friction losses, the load is constant at all points in the lift and the mechanical strains are equalized except when starting and stopping. For some shafts and inclines this system lacks flexibility, since no independent trips can be made in either of the two compartments and a change to winding from different levels is attended with considerable loss of time. However, the evil effects of lateral deviation of rope in winding on a drum is done away with, as is also the deleterious crushing effect of the outer coils of rope on those below and the combined effect on the drum. Sinking cannot be conveniently done with this system; but the better practice would be to use an auxiliary hoist for this purpose, so as to leave the main plant free for other uses. These hoists are all in operation excepting the 200 horsepower at the C. & C. shaft, and too much cannot be said in praise of them. They are as easily and perfectly handled as any steam hoist or elevator and the starting impulse causes less than a 7 per cent. drop in voltage. They do not blow fuses and the controllers give no trouble.



75 HORSEPOWER INDUCTION MOTOR DRIVING TWO-STAGE AIR COMPRESSOR AT THE YELLOW JACKET MINE.

The Yellow Jacket hoist was operated for some time with a single cage in one compartment with the following results:

| | |
|---|---|
| Weight of cage | 1200 pounds |
| Weight of car | 850 " |
| Weight of rock | 1600 " |
| Total weight lifted | 3450 " |

Maximum speed, 600 feet per minute.
Length of vertical lift, 1175 feet.
Time of hoisting and landing, 2 minutes and 3 seconds.
Time to accelerate load, 8 seconds.
Power required, 88.40 horsepower.
Theoretical power required, 66.40 horsepower.
Efficiency, about 75 per cent.—this includes motor inefficiency and all friction.
Voltage, 525; drop at starting, 25 volts.
Maximum starting current per phase, 180 amperes.
Full load current per phase, 85 amperes.

I have not had an opportunity to test the efficiency under balanced conditions; however, the above is slightly in excess of the duty when operating double deck cages, balanced.

This hoist has made twenty trips per hour from the 1200-foot level with single deck cages, thus showing a daily capacity of over 350 tons. This may be increased to 600 tons by using double deck cages, and at this rate the power would cost a little more than 2c per ton hoisted.

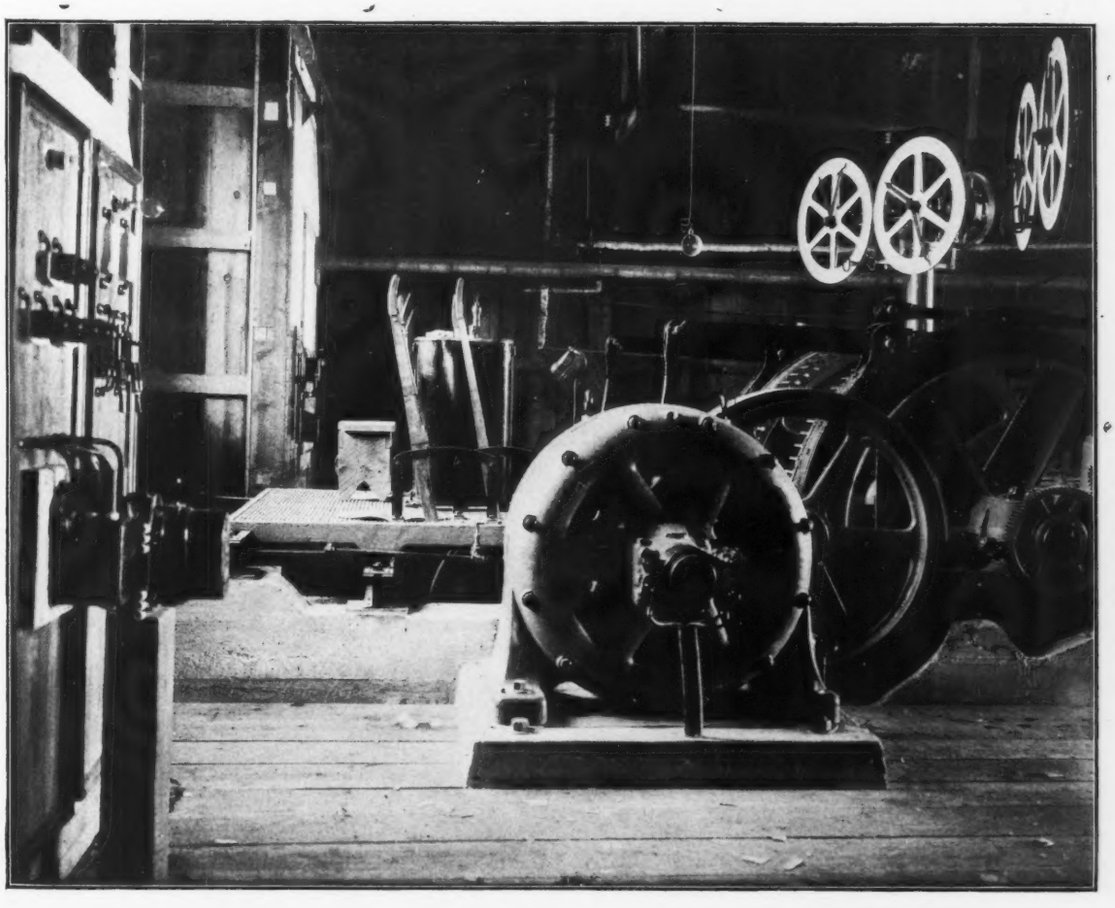
In conclusion I will add that the successful operation of this hoist is a decided advance in mine hoisting, not alone in the high efficiency secured, but also in its large capacity, as compared with the size of the motor in use. We have not overlooked the apparent reduction in the load factor of the power plant, on the other hand have materially increased it by reducing the size of the motors to a minimum, so that they will be in almost continual operation. Similar service with compressed air would necessitate a motor of more than twice the size, owing to the inefficiencies due to compression and air engines.

Hot water in enormous quantities has been the bane of our existence and up to the time the mines were flooded, the ablest engineering talent in the world was doing its utmost to keep the mines free from water and upon a dividend paying basis. At this time some of the most prodigious machinery was in use, as will be observed from the following descriptions and the accompanying photographs.

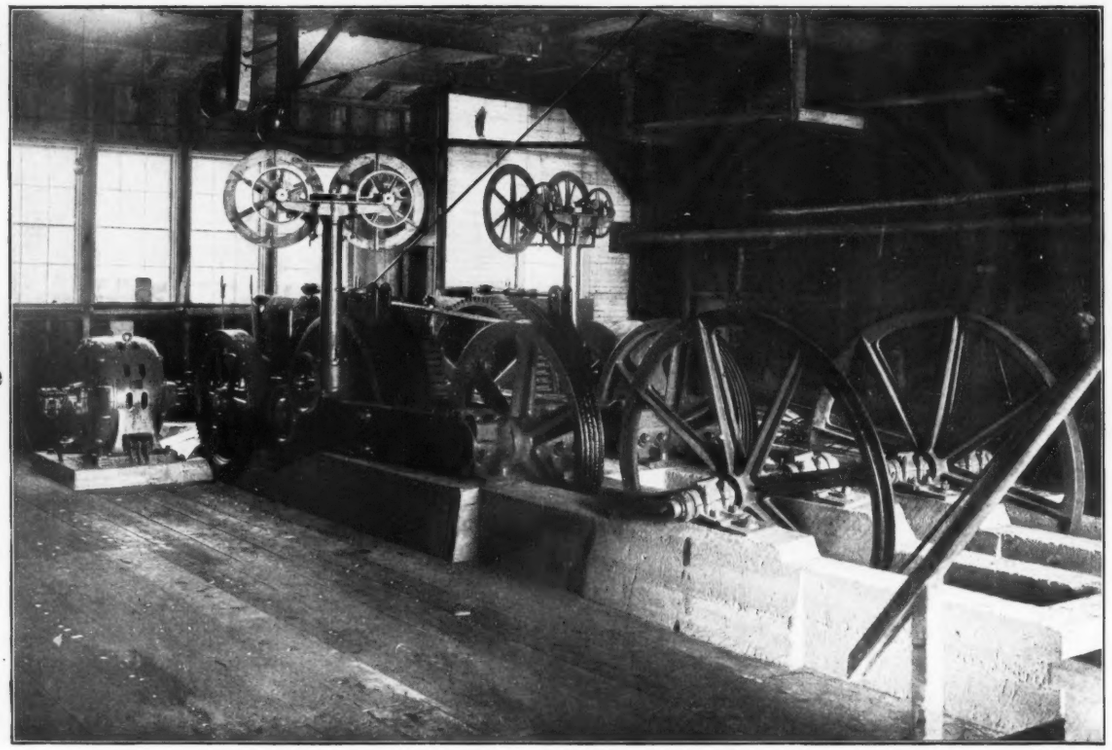
The Union Shaft Pump was what is generally known as a direct acting Cornish pump of the fly-wheel patterns, and consisted of a double line of 17-inch pumps with 10-foot stroke. These were driven by a compound engine with inclined cylinders and an inverted walking beam. The initial cylinder is 64-inches in diameter and 6-foot 9-inch stroke; the low pressure cylinder is 100 inches in diameter with 8-foot 6-inch stroke. The air pump is 54 inches in diameter with 6-foot stroke. The fly-wheel is 36 feet in diameter and weighs 208,700 pounds. The wrought-iron walking beam is 22 feet long and weighs 238,610 pounds. The pump rod is 18x18-inch Oregon pine and 2618 feet in length. The total weight in motion was 1,620,500 pounds, or about 620 pounds per foot of pump rod. The capacity is about 750 gallons per minute to a height of 1180 feet. This pump was started in 1880 and did good work, but was very expensive in its operation.

20 HORSEPOWER ELECTRIC HOIST AT THE SIERRA NEVADA MINE.

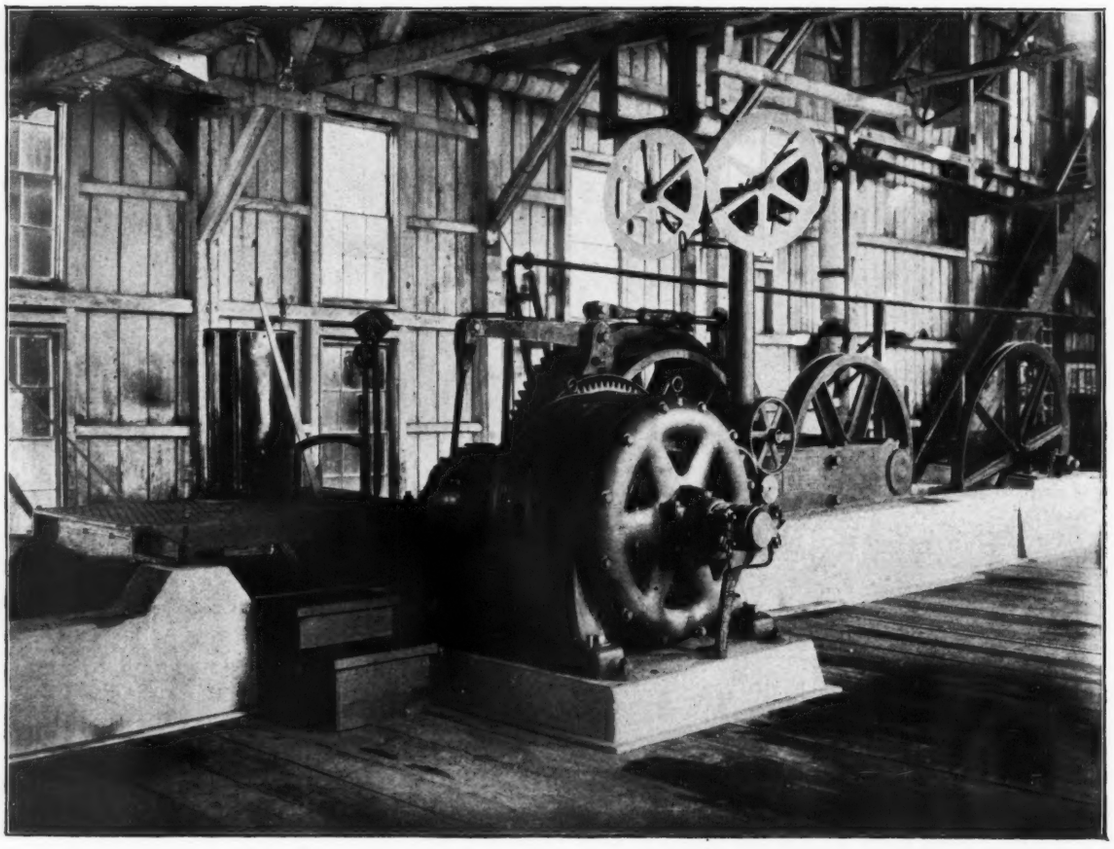
The Yellow Jacket Pump consisted of a double line of



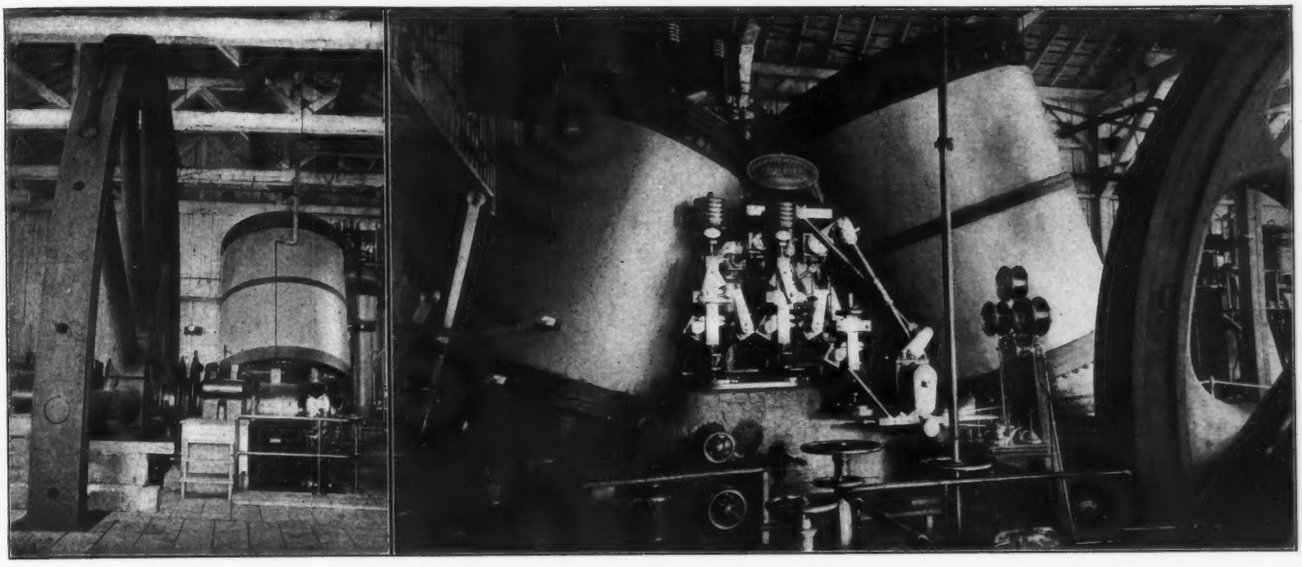
75 HORSEPOWER VARIABLE SPEED MOTOR AND CONTROLLER ON THE BELCHER HOIST.



THE ELECTRIC HOIST AT THE BELCHER MINE.



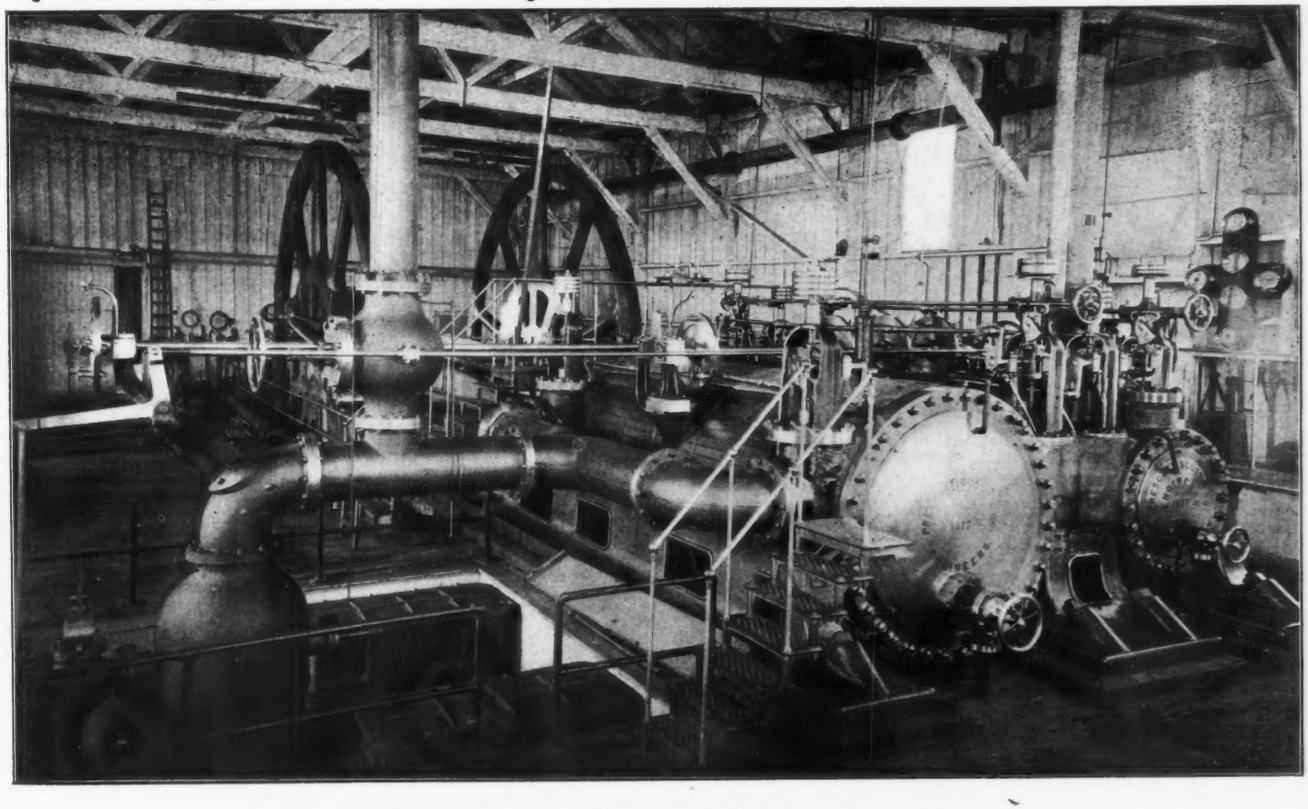
100 HORSEPOWER ELECTRIC HOIST AT THE UNION SHAFT.



ORIGINAL PUMPING ENGINE AT THE UNION SHAFT.

14-inch pumps with stroke of 10 feet. It was driven by a horizontal compound engine with double box-truss castings 64 feet long for the bed plate. The initial cylinder was 31 inches in diameter with 12-foot stroke and the low pressure 62 inches in diameter with 12-foot stroke. Crosshead was of wrought-iron and weighed 11 tons. There were two 30-foot fly-wheels weighing 110 tons. The pump rod was 3055 feet long, and the weight in motion was 1,510,400 pounds. With steam pressure of 130 pounds at 5½ revolutions per minute, this machine developed 422 indicated horsepower, and at this time was raising 432 gallons per minute 3000 feet with a single line of 14-inch pumps. Later it lifted 750 gallons per minute 1516 feet.

Combination shaft pumps consisted of a 14-inch Cornish pump and a hydraulic pumping plant. The latter was operated by pressure from the surface and discharged into the Sutro tunnel. About the time that the mines were allowed to fill, this hydraulic system was lifting 2128 gallons per minute and the combined capacity



PUMPING ENGINE AT THE YELLOW JACKET MINE, NEW SHAFT.

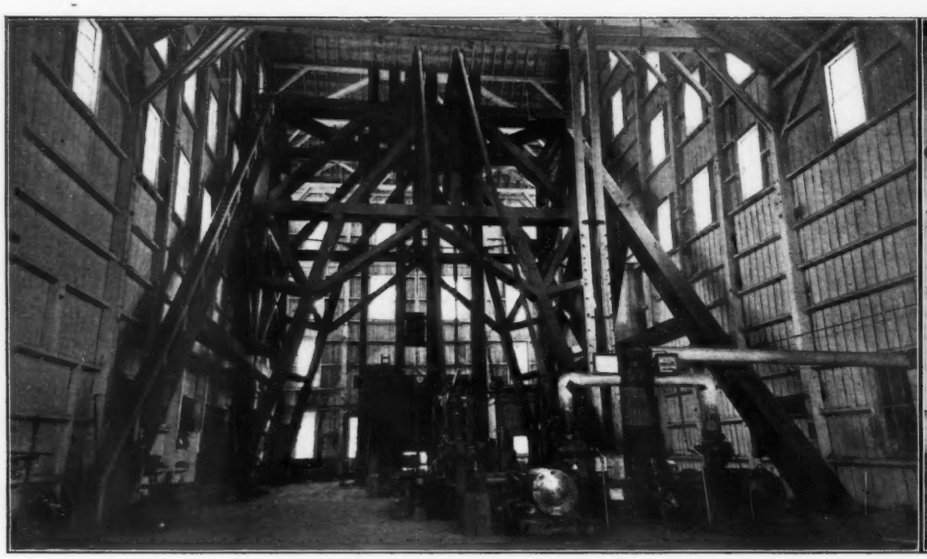
of all the Cornish pumps was 2912 gallons per minute, or a total of 7,257,600 gallons per day. Two and seven-tenths miles of pump rod, that weighed 2230 pounds for every gallon of water pumped, or a total of 6,496,400 pounds, was started and brought to rest at an average of nine times per minute. The total cost of these pumps was over $2,500,000 and the cost of operation $34.13 per horsepower per month, with wood at $10 per cord. For the above data I am indebted to Mr. W. R. Eckart, who made some extensive tests upon these pumping plants.

About twelve years ago an attempt was made to unwater the Gold Hill mines with pumps operated by compressed air, and after an expenditure of $640,000 the attempt was abandoned without having lowered the water 300 feet. This was rather discouraging, but another attempt was made in 1899 and it now bids fair to be successful. Hydraulic elevators were installed in the C. & C. shaft and with them the water has been lowered 450 feet. Under our existing conditions I believe this device is the most practical sinking pump in existence. True, that the efficiency is only about 25 per cent. at best, but the cost of repairs is very small and the reliability all that could be wished. At a depth of 450 feet below the Sutro Tunnel level we have about reached the limit of power from our water supply, and we are now preparing to install a large electrical pumping plant, on the 2150-foot level, which will have a capacity of 4500 gallons per minute. This is designed to take not only the mine water, but also the pressure water from the elevator temporarily, or so long as it is used as a sinking pump. As soon as the shaft is free from water it is our intention to supplement these electric pumps with another on the 2,550-foot level. The elevator will then be abandoned except as a reserve in case of accident to the electric.

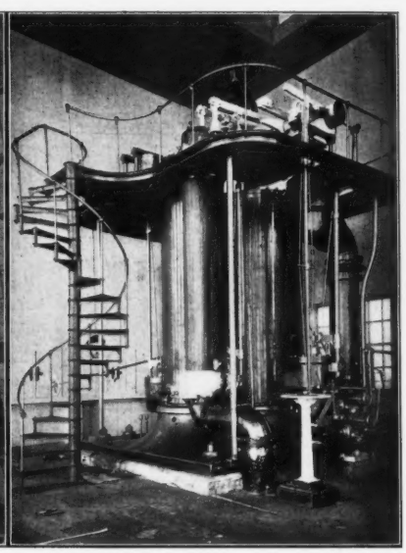
As shown upon the accompanying diagram, this plant will consist of three duplex, double-acting (6-11-16x24 inches) pumps, driven by three 225-horsepower Westinghouse type C motors. The pumps will be of the ordinary Reidler pattern, with mechanically closed valves, and will operate at 110 revolutions per minute. The motors are special 3-phase, 60-cycle, induction motors, and will operate at 495 revolutions per minute. These motors are to be geared by a single reduction to the pumps with cut cast-iron gearing and steel pinions with stepped teeth. The gearing is to be housed and practically run in oil.

Each pump will be independent of the others, so that an accident to one will not seriously interfere with our service. The current for the motors will be taken from the surface by means of a lead-covered, iron-armoured cable of 2240 volts, and will be used at this potential. The pump station is to be 17 feet 8 inches wide, 18 feet high and 110 feet long, in the clear, and it will be timbered with 14x14-inch pine posts, caps and sills and 3-inch planking. Concrete will be used for foundations, and a traveling hand crane will move from one end of the station to the other. The station will be cooled and ventilated by a small motor-driven fan; it will be lighted with incandescent lamps, and a telephone circuit will give direct communication with the power house at Floriston. On this circuit besides the integrating wattmeter, we shall have a synchroscope, a power factor meter and a static ground detector, so that we may know exactly, at all times, what we are doing. Compared with our former pumping plants this one is a marked advance in engineering methods; the cost, about $60,000 in running order, is but a fraction of what was formerly paid, and the running expense for 675 horsepower will be $4725 per month, which is about one-third of what it cost to operate the hydraulic at the Combination Shaft, using about the same power.

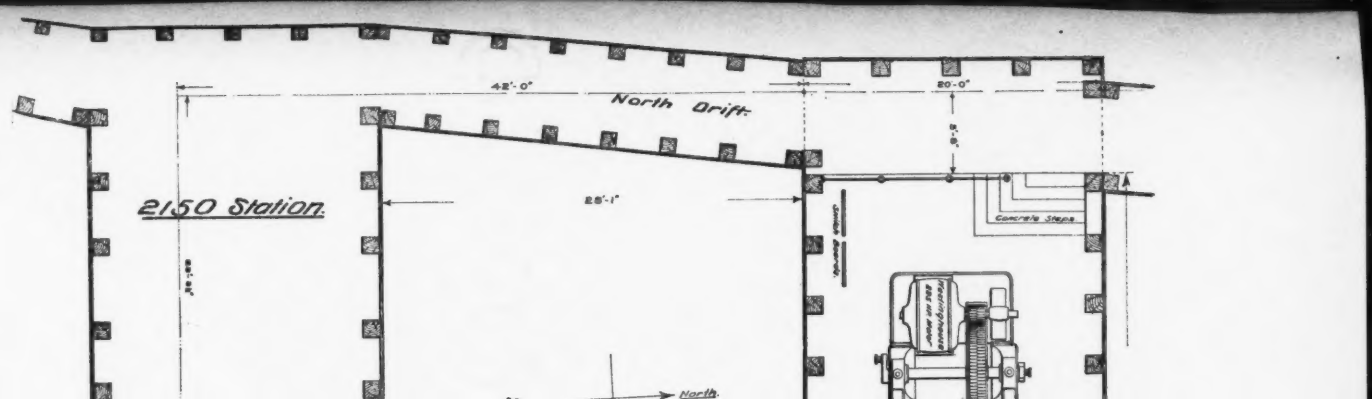
Finally, it gives me pleasure to state that our electric installation has thus far been a marked success. It has given good service and satisfaction, and, last but not least, we feel assured that it will be the ultimate means of "pouring more millions into the world's coffers."

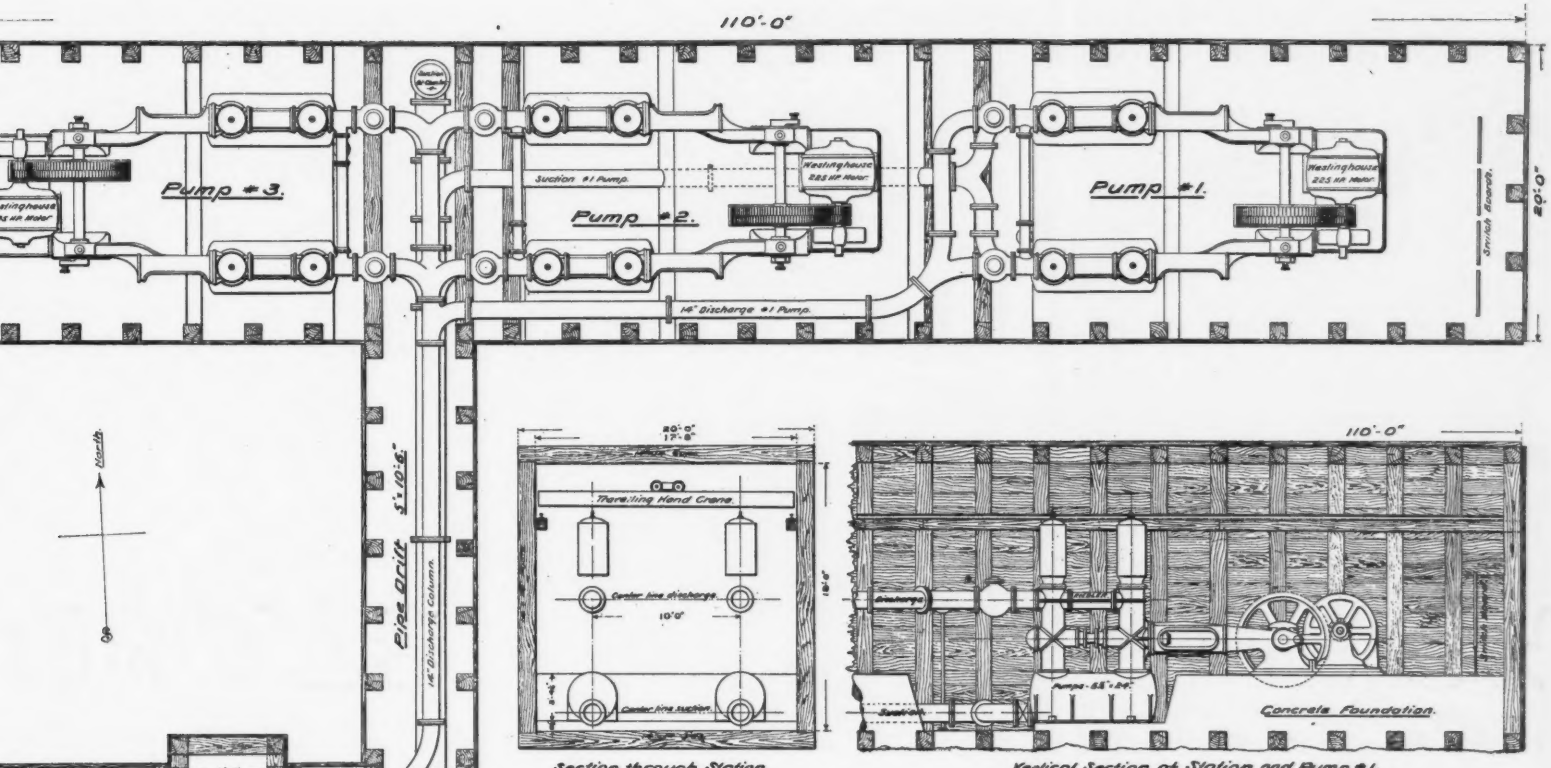


THE GALLOWS FRAME OF THE FORMAN SHAFT.



PUMPING ENGINE OF THE FORMAN SHAFT.


42'-0"
North Drift
20-0"
2150 Station
25'-1"
Concrete Steps
A
North




# Pumping Station
— on the —
## 2150 foot level of the C. and C. Shaft.
Virginia City, Nevada.

Scale 1" = 1'.

## DISCHARGE NOZZLES FOR HIGH HEADS.

*BY W. STUART SMITH.*

REFERRING to the point raised by me at the recent convention of the Pacific Coast Transmission Association as to the cause of the pitting in the nozzle shown by Mr. Eastwood, I think there is absolutely no doubt that it is a case of oxydation and not cutting. The appearance of the pits is most characteristic of chemical action and totally unlike any effect that can be produced by cutting. It may appear impossible that any chemical agent can maintain itself on the surface of a nozzle through which water is flowing with very high velocity, but I think it easily possible in the case of improperly proportioned nozzles.

At first sight it may appear paradoxical, but it is nevertheless a fact, that far more severe oxydation of iron placed in water will occur if there is high relative velocity between the two than if the iron is resting quietly in the water, but in order that this may be the case, certain peculiar conditions must exist which will result in the production, next to the iron, of zones wherein the pressure of the water is less than in the body of the water outside these zones.

It is a common error to speak of the air absorbed by water freely exposed to the atmosphere, the idea usually entertained being that the gases so absorbed are simply a portion of the atmosphere taken without choice as to constituents. As a matter of fact the affinity of water for oxygen is much greater than for nitrogen, and of the occluded gases in the water the greater portion is oxygen, and the gas liberated from water is very rich in this element. Moreover, in water the oxygen does not exist in a free and independent state as a simple mixture, but is in solution. There is considerable mystery about the nature of solutions, but it is certain they are in some manner chemical combinations rather than simple mixtures, and when oxygen is being liberated from the water it has almost the chemical activity of so-called nascent oxygen.

Of the gas in solution with the water, a portion will at once be liberated if the pressure on the surface is reduced. This is shown by placing a vessel of water under the bell of an air pump and exhausting. At almost the first stroke of the pump air bubbles will begin to separate from the water and rise to the surface.

If a solid is immersed in water, or an equivalent relation exists, such as water in a pipe, and there is considerable relative motion between the two, it is possible under certain conditions for zones or regions to exist wherein the pressure of the water is less than in the outlying regions, and in these zones gas (mainly oxygen) will be liberated from the water and adhere with considerable force to the surface of the solid, particularly if this solid is one for which oxygen has strong chemical affinity, as is the case with iron. As almost pure oxygen then exists in contact with the iron in the presence of moisture rapid pitting will occur.

Take as an example the case of a screw propeller. Let Figure 1 represent a section of a propeller blade, *a* being the leading edge and *b* the following edge. The straight line is the working or go-ahead face. When driving the vessel ahead motion will be in the direction of the arrow. The forward motion of the vessel, of course, drags the back of the blade against the water, and if the propeller was not revolving the water would exert strong pressure against this portion; but as the propeller revolves the following edge, *b*, and adjacent area of the back of the blade are continually receding by an amount equal to the pitch of the screw multiplied by the revolutions per minute, and as this speed of recession is greater than the speed of the ship by an amount equal to the slip of the propeller, the tendency of the forward motion of the vessel to produce a pressure on the back of the blade is more than overcome, and there is a considerable portion of the back of the blade upon which the pressure is less than in the surrounding water. Oxygen separates from the water and clings to this part.

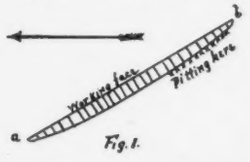


Fig. 1.

Cast-iron propellers on vessels making long voyages corrode greatly on the following portion of the blades, the corrosion being greatest near the tips, where the motion is greatest. Old cast-iron blades become fairly honeycombed in that region and sometimes have the ends cut off and new ones burned on.

A similar action occurs on the backs of turbines and in the same relative position, i. e., near the points of highest velocity, and has been the cause of much trouble.

In discharge nozzles for high heads, as used in Pacific Coast transmission plants, zones of diminished pressure may occur if the nozzles are improperly proportioned. Figure 2 illustrates this. With high spouting velocity the stream lines tend to persist with great force, and those coming from the slopeing sides of the nozzle will attempt to cross the axis. They are prevented from doing so by the reaction of the central portion of the stream and are forced to move in curved lines as shown, leaving behind them a zone, *aa*, in which the pressure is less than in the body of the stream, and in which oxygen, separated from the water, will tend to collect.

Though there is a tendency for oxygen to collect in this zone, it may or may not be permitted to do so according to the circumstances. If it does collect there will certainly be oxydation, and the appearance of the pits in the exhibit made by Mr. Eastwood is such as to lead to the conviction that it did collect in that nozzle.

With short and improperly shaped nozzles the zone behind the stream lines will always exist, but its relation to the stream and the effect it will be responsible for will depend upon the proportions of the nozzle. It may happen, first, as in Figure 2, that the discharge will just graze the edge of the orifice and form a completely enclosed zone; or, second, if the straight portion of

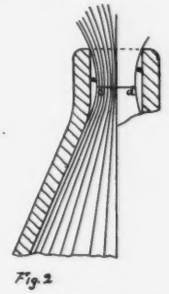


Fig. 2

Fig. 3

Fig. 4.

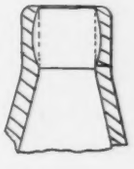


Fig. 5.

The nozzle can discharge no more water than will pass section *c d*. Such a section as *c d* must always exist.

the nozzle is shorter or the stream lines flatter the zone will be open, as in Figure 3; or, third, if the straight portion is longer or the curve sharper the outer portion of the stream will impinge on the nozzle, as in Figure 4.

In the latter case there will be cutting by impact with a tendency entirely and evenly to cut away the outer portion of the nozzle; but if soft spots exist in the casting or small blow or sand holes be encountered, into which the stream can impinge and be turned, irregular pitting will take place, but the appearance of such pits will be very different from that of pits caused by chemical action.

Mr. Eastwood regarded the pitting in the nozzle exhibited as due to impingement of irregular stream lines on the surface, these irregular stream lines being due to the natural agitation of water discharging at high velocity, but such irregular stream lines are absolutely foreign to the natural flow of high head discharges. The tremendous force with which the particles of water persist in maintaining their direction of motion will cause a flow in definite stream lines, it being just this persistance or objection to change of direction of motion which causes a fluid under very high velocity to partake of the nature of a solid. Fluids are distinguished from solids by the fact that their particles are capable of free movement in any direction, while particles of a solid are relatively fixed, and high spouting velocity causes a fluid to

(*Continued on page 158.*)

THE JOURNAL OF
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GEO. P. LOW, EDITOR AND PROPRIETOR
Postoffice Station M.

Address all business communications to
J. M. SHAWHAN, BUSINESS MANAGER
144 Union Square Avenue ('Phone Bush 519), San Francisco, Cal.

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VOLUME XII AUGUST, 1902 NUMBER 8

## EDITORIAL.

**REFERRING TO OURSELVES.**

The general prosperity that prevails throughout the country has led to the expansion of nearly every successful business enterprise in the Union, and THE JOURNAL has joined the expansion parade.

It is not often that THE JOURNAL has had occasion to refer to itself; but there are times in the career, not only of publications but of individuals, when they feel it a pleasurable necessity to take their friends into their confidence for mutual benefit and advancement.

Such a time has arrived for THE JOURNAL, and we trust our friends and patrons will give the paragraphs following the same kind attention that has characterized their perusal of THE JOURNAL columns in the past.

The increase in circulation and the consequent enlargement of the business features of THE JOURNAL have necessitated the introduction of a "business manager," who will assume all the duties connected with the mechanical and business department of the publication. This will leave the editor free to devote his entire time to the reading columns of THE JOURNAL, a condition of affairs that will no doubt be as heartily welcomed by the readers of THE JOURNAL as by Mr. Low himself. The natural forecast of the result is that THE JOURNAL from this time on will be more readabie than ever, and contain many attractive new features that for lack of time have not been introduced in the past.

It is but fair to state, also, that new capital has been infused into THE JOURNAL, and that before long it will be incorporated with a board of directors the personnel of which will be a guarantee not only of stability and worth, but also of a greater activity in the world of power and energy.

The introduction of new capital and the active work of additional brains will necessarily mean an enlargement of THE JOURNAL in the scope of its subjects, its reading matter and advertising columns, and it is the present purpose to make it the leading exponent in the West of power from whatever source generated or in whatever manner distributed.

Mr. Low will gather about him as associate editors leaders in the fields of oil, gas, air, steam and water, and the progress of the entire power world in the West will be placed before our readers from month to month.

Many improvements are contemplated for the near future which will as they appear, be fully noted and appreciated by our readers and patrons. This month, by way of illustration, we print the journal on a very fine grade of paper, so as to bring out more clearly the text of our articles and show to the best advantage the fine half tones that have always been a leading feature. You will like them better than ever on our new plate paper.

We cannot complain of the support we have had from you in the past. It is entirely through your appreciation, expressed in advertising and subscriptions, that THE JOURNAL has achieved its present position and success. All we ask for the future is a continuance of the cordial relations between you and us that have made our work so pleasant heretofore.

Within the last few months it has been our good fortune to receive a number of letters from subscribers making timely suggestions that have been very welcome and useful. We trust that we may still continue to thus keep in touch with our friends, and cordially invite correspondence of this class from all of our readers. It is always a pleasure to hear directly from our patrons.

Apropos of letters, it is with an excusable pride that we quote one received from the general manager of The Smuggler-Union Mining Company, Colorado, the occasion being the remittance for renewal of subscription. The letter reads as follows:

TELLURIDE, COLORADO, 7/25, 1902.

*Geo. P. Low, Ed. Jour. of E. P. and G., San Francisco, Calif.:*

DEAR SIR—I enclose herewith check for $1.00 in payment of another year's subscription to your valuable paper. Permit me to say that I regard it as perhaps the best dollar's worth that I know of to one interested in power development. The wonder to anyone familiar with THE JOURNAL is that you can produce it in any such style for any such price.

Very truly yours,

C. W. VAN LAW.

We can stand a great many such letters, but in addition to praises for THE JOURNAL, would appreciate suggestions for the betterment of the publication.

While we have been favored with a reasonable share of advertising, our columns have not had the representation that they should have, especially as the charges for the

service rendered, in comparison to cost of advertising in similar Eastern publications, is ridiculously low. To justify the contemplated improvements to be made in THE JOURNAL, we want your business to be represented, and hope to see a material increase in the number of our advertising pages before January 1st, next.

THE JOURNAL at present is the lowest priced technical publication in the United States, and that we cannot afford to publish it much longer at $1.00 a year must be patent to all our readers. The cost of subscription to THE JOURNAL may be doubled on and after January, 1903, and we would therefore recommend to all intending subscribers that they forward their names at once and get the benefit of the present low rate of subscription.

Our circulation has now reached the 3000 mark, and considering how many copies are bound annually and kept as a reference work, we cannot but feel that we are to be congratulated on reaching that number of discriminating readers who hold us as of value. We want your friendly recommendation to assist us in doubling this list. If *you* like THE JOURNAL and find it of interest and value to *you*, your friends in the mechanical fields may, by having their attention called to it, find THE JOURNAL welcome and useful to them. We will gladly forward on application sample copies to any address, and hope *you* will send us in the names and addresses of several of your friends to whom we can mail complimentary copies.

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**WATER WHEELS AND STEAM TURBINES.**

In competitive industries, phases of temporary advantage ofttimes swing from side to side seemingly in consonance with true polyphase curves, and when power producing machinery is viewed in this light, interest centers in the preferences which have taken place in prime movers of the various kinds for the operation of generators, as well as in the types of generators themselves. Originally, when science gave birth to the electrical industry, the prime movers available consisted in slow moving turbines and slower moving engines. On the other hand, the dynamos which had been developed were possessed of armatures designed to run at high rates of revolution, to attain which, driving pulleys of large diameters were run from prime mover shafts and driven pulleys of small diameters were attached to dynamo shafts, thus satisfying the high speed requirement of the latter. But this arrangement entailed unnecessary losses and annoyances of a mechanical nature, to reduce which the speed of steam engines was increased and the speed of armatures was reduced, so that the ratio of reduction between prime mover and dynamo would not be so great. Then came the present era of direct connection.

However inflexible the turbine has proved to be as to speed requirements, the development of the tangential water wheel has fulfilled every stipulation, so that long before the day of large direct connected steam and electric units, direct connection between tangential water wheels and generators of large capacity had become an established custom. Nevertheless the serious effort in high head plants has been to keep the diameters of water wheels down so that the speed would be moderate and in conformity with modern central station practice. Meanwhile steam driven generators have been growing larger and larger until now they have reached truly mastodonic proportions, and so marked has been the tendency in this direction that the trend of development toward larger and larger generators has appeared to be settled down into a fixed position. But a halt is very likely to be called stopping further advance in this direction, for the commercial perfection of the steam turbine has shown the futility of building engine and generator sets as big as buildings, as well as pointing out the wisdom of returning to first principles of dynamo construction, wherein high speed of rotation on the armature (or fields) was accepted as good practice.

Lest some apprehension exists that the development of the steam turbine is destined to be the means whereby electrical energy may be produced from steam more cheaply than by water power, it may be well to indicate that the high speeds of the steam turbine in its commercial form may be developed with equal ease by water wheels of the tangential type, and that whatever is resolved into good practice for the one will be equally good practice for the other. More than this, let us hail the return of high speeds with delight, for has not the 3600-revolution, 7200-alternation bipolar alternator, as developed by the perfection of the steam turbine, brought home the lesson to transmission interests, and especially to transmissions which operate power houses under high heads, that the size and cost of generators go down as generator speeds go up, and that, therefore, the minimum of generator cost is to be reached when bipolar alternators are used and driven at such speed as will give the frequency required.

Clearly, then, the day of the installation of the mammoth generator driven by a tangential water wheel of great diameter, which in turn is operated by water at high head, will soon be of the past.

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The Northern California Power Company, successor to the Keswick Power Company, has received an additional 1000-horsepower Westinghouse generator. The new apparatus will be installed at once in the 4500-horsepower electric station on Mill Seat Creek. There is sufficient water for developing 12,000 horsepower. The transmission line will be extended from Palo Cedro to Red Bluff, Tehama and Corning.

---

A report has reached this country as to the formation at Milan, Italy, of a new company with $16,000,000 to consolidate light and power plants. It was thought this applied to local enterprises, but it is now stated that the intention is to acquire water power for electrical purposes throughout Europe.

## DISCHARGE NOZZLES FROM HIGH HEADS.

(*Continued from page 155.*)

partake of the nature of a solid by causing the particles to have a relative fixedness of position with respect to each other. I think the condition illustrated in Figure 4 is the only one in which any impingement is possible.

Some years ago a nozzle was shown me in which the entire length of the straight portion was smoothly and evenly hollowed out, as shown in Figure 5. There was no pitting, but only an even, smooth cut, and it was probably caused by an eddy behind the stream lines which carried particles of sand around and around and cut the metal away by abrasion. It is probable that this would occur in such a case as Figure 2, where the stream just grazes the edge of the nozzle and forms a closed zone. In such a case probably no pitting could take place, as there would be no impingement of water on the metal and the sand would sweep out the oxygen. The particular nozzle mentioned was cut within a few days after the starting of the plant and while there was still much sand and grit in the pipe. Later it is possible the water would be clean and oxygen collect and corrode the tip, the wash of the eddy alone, unaccompanied by sand, not being sufficient to oeercome the cohesion between the oxygen and the iron.

It is therefore possible that a nozzle may be cut by abrasion, cut by impingement and corroded by oxydation, and possibly under favorable conditions both oxydation and cutting by impingement may occur at the same time.

Water allowed to flow through and discharge from a contracting nozzle must, for some portion of its length, have its stream lines curved, and such a stream will always spread after passing its contracted vein if it is not constrained to move in the direction of a tangent to the curve at the smallest section, i. e., parallel to the axis. To accomplish this it is necessary to make the curve joining the straight portion of the nozzle with the conical portion conform to the natural curve of the stream lines after passing the conical portion.

At the narrowest part of the contracted vein the stream lines are flowing parallel to the axis and in the desired direction of discharge, and if a straight part of exactly the diameter of narrowest section begins just at that point it will not be obliged to *turn* the stream lines, but only constrain them to continue in the direction in which they are already flowing. The force required to do this will be small, as a moments consideration of the conditions will show. The stream tends to continue its direction of flow parallel to the axis with great force, but the internal forces are just sufficient to overcome this and cause them to bend outward. That this excess of force is very small is evident from the fact that the lines curve gradually outward, whereas if the force was great the stream would be violently broken. Therefore the straight portion will have to exert but a small reaction to hold the stream parallel to the axis. There will be no impact, since the stream lines at that point are parallel to the axis, but only a pressure against the stream, this pressure being small because the forces are naturally nearly balanced.

It is imperative, however, that the straight part begins exactly at the smallest section of the contracted vein and has exactly the diameter of this part. If it extends back of this point it will press into and cause distortion of the stream, and if it begins forward of this point the stream will have begun to curve out and will impinge on the nozzle and cut. If it begins at exactly the right point it will cause a perfectly steady flow parallel to the axis, the stream being in no way agitated.

There being no impingement and but small pressure there will be practically no cutting if the nozzle surface is smooth and continuous. If there are small sand holes in the surface, just forward of the smallest section of the contracted vein, the beginning of the straight part will virtually be pushed forward at those points, and a small portion of the stream, not having a surface to constrain it to move parallel to the axis, will impinge into and enlarge the holes. As it is almost impossible to have a casting that will machine free from small holes it is better that the straight part be made of processed metal and inserted.

In designing a nozzle the laws governing the flow must be favored and not antagonized if satisfactory results are to be expected. Made in conformity with the natural shape of the stream lines, nozzles will have the water flowing smoothly and in close contact at all points. There will be no impingement or agitation of the water, no place for sand or oxygen to collect, and no eddies.

The vast majority of nozzles combat the laws of flow instend of conforming to them. The usual way is to lay down a straight part having the desired diameter of discharge, lay down a conical part to connect with the gate, join these by any old curve that appears fair to the eye and leave the water and nozzle to fight it out. The battle is generally a hot one.

This is all wrong. In the drawing room it is possible to fix but two dimensions. The diameter of discharge must be calculated so as to deliver the quantity of water required to develop the desired power and the diameter of the base of the conical part may be assumed, but all other dimensions must be determined by experiment. The length and angle of the conical part must be varied until the narrowest section of the contracted vein has the calculated area of discharge, the straight part must have that diameter and begin at exactly the smallest section, and the curve joining the two must correspond exactly with the stream lines as they would be if the water discharged freely into the air from the smallest diameter of the cone. Nozzles so made will be subjected to practically no pressure except on the straight sides of the conical part. From templates a mandrel must be made having exactly the shape here indicated, and the nozzles must be carefully machined to the mandrel. In no other way can a non-cutting nozzle be made which will deliver a stream of the greatest possible efficiency and with minimum loss of head. An internal directing device, such as a needle, will cause a good discharge from a badly designed nozzle, but the friction will be much greater than in a nozzle designed as herein specified.

It is necessary to vary the length and angle of the conical part until the narrowest section of the contracted vein has the calculated diameter of discharge, because this section absolutely determines the quantity of water discharged, and no matter how great may be the diameter of exit, no more water will pass through than is equal to the smallest area of the contracted vein multiplied by the velocity of flow at that point. Failure to give due regard to this will result in a failure of the wheel to develop the expected power, because, not only will the stream be a spreading and inefficient one, but the quantity of water delivered will be less than the calculated amount.

Properly designed a nozzle will not pit, and a nozzle which does pit will always discharge an inefficient stream. These are facts capable of easy demonstration. They result directly from the laws of flow.

A nozzle having the proper form for one velocity of discharge will not be exactly right for another velocity such as will be obtained by throttling down and working at partial gate. This is due to the fact that with every change of velocity the position and diameter of the contracted vein will vary. Nevertheless a nozzle which will fill at highest velocity of flow will continue to fill when the velocity is reduced, owing to the fact that at reduced velocity the contracted vein will shift backward and increase its diameter instead of being pushed forward and reducing its diameter.

Spiral flow may (possibly does) sometimes take place in the pipe, but can easily be stopped before the water enters the nozzle. The cause is, I think, understood. It is the resultant of two forces; one, the persistence of each particle of water to maintain its flow in a given plane, and the other the rotation of the earth on its axis, forcing the moving particles into continually changing planes, the resultant being movement in a spiral. An appreciable time is required for such spiral motion to become evident, and if the stream approaches the nozzle without such motion it is exceedingly doubtful whether it can possibly acquire it in the short time during which it is discharging.

## THE STATION TRANSFORMER HAZARD.*

*BY GEO. P. LOW.*

IT will be an easy matter to remember the function of an electricity transformer if the word "transformer" be prefaced with the noun "voltage," giving the compound word "voltage-transformer," that is, a changer of voltage or electric pressure. The term "converter" was formerly used interchangeably with the word transformer as indicating one and the same device, but the electrician speaks of a converter as being a mechanism by means of which electricity may be changed or converted from one variety or form of current to another without regard to the voltage of either. A rotary converter, for instance, converts alternating current into direct current, while a static transformer will absorb alternating current at a pressure of, say, 11,000 volts, and deliver a practically equal amount of electrical energy in the form of alternating current at, say, 2400 volts. Transformers are invariably alternating current devices—they cannot be otherwise. Converters, however, are a sort of a composite dynamo and motor mechanism which may be adapted to handle any and all varieties of currents and voltages. The hazards of converters are those of dynamos or motors, which are well understood and under easy control, but those of transformers may well be made the subject of long and patient investigation.

As to the principles of operation of transformers, let it be remembered that electricity is generated in the armature of a dynamo by the passing of a wire in front of a magnet. The requisites to the generation of electricity by this method are motion and magnetism. In some dynamos the magnet passes by a stationary wire, in others the wire passes by the magnet. It is immaterial which procedure is followed so long as the essentials of motion and magnetism exist about a wire. Now if we examine the make-up of a transformer, it will be found to consist of an iron core, which forms the magnet, a coil of wire (called the primary coil) which gives magnetism to the iron core, and another coil of wire (called the secondary coil) which takes magnetism from the iron core. The primary coil and the iron core may be regarded as a unit in the development of magnetism in the transformer; that is, they together form the electro-magnet. But this electro-magnet is energized by alternating current which oscillates, say, sixty times per second; hence the magnetism moves, first positive, then negative, then positive again, and so on. Here we have a condition exactly parallel with that presented in the dynamo. The magnetism moves through the wire forming the secondary coil, generating current therein by doing so. In other words, in the dynamo a wire moves through a magnetic field and electricity is generated in the wire, while in the transformer a magnetic field moves through a wire and electricity is generated in the wire as before.

Thus it is that in a transformer energy is delivered from its primary coil to its secondary coil in just as positive a manner as is done when a water wheel or a steam engine delivers power to the dynamo it drives. A transformer having a capacity of 1000-horsepower is an insignificant piece of apparatus in comparison with a steam engine of equal capacity. There is no more energy involved in the smash-up of a 1000-horsepower steam engine, nor as much, in fact, than there is in the burning out of a 1000-horsepower transformer. An engine that is wrecked is demolished by the energy of its own effort plus the momentum of its fly-wheel, but the transformer which burns out has centered in its destruction, it may be, all the energy of every unit in the power house behind it. This explains the quickness and the viciousness of transformer burn-outs.

It is an inexorable law that as the distance covered by transmission lines go onward the limit of voltage used shall go upward. The time was but eight years ago when 10,000 volts was regarded as little short of terriffic, but today 40,000 volts has long been in regular service, 80,000 volts has been used on transmission lines experimentally, and 120,000 volts is in common use hereabouts in testing work. The use of these constantly increasing voltages has rendered it necessary that something more than the insulation of fibrous materials and air should be used in transformer building, and the practice of immersion of the transformer into oil came into vogue. It was one of those cases which simply had to be, for no alternative was presented or could be devised despite the fact that the use of oil above all else was bound to be the cause of great concern among fire underwriters, as well as to electric station managers themselves.

The oil itself is selected with the greatest possible care, for it is essential to the welfare of the transformer which it insulates that it should be absolutely free from acids, mineral compounds or anything which could possibly exercise a deleterious influence on the materials of the transformer. Its fire test is high, as the records of your inspection bureaus attest, and if viewed from its electrical standpoint its insulating and puncture resisting qualities are perfect. If incipient trouble developes in a transformer that is oil-insulated, the oil rushes in and heals the wound, making ofttimes a perfect cure. If a flash or spark of any ordinary nature takes place within the transformer case, which is probable with dry transformers, but practically impossible with oil-filled ones, the oil would instantly choke off the spark and restore the insulation to its normal state.

Under normal conditions, therefore, the use of oil is a necessity of the greatest possible good; the term normal being used in the sense implying the usual working conditions as at present installed and operated. It is not unusual in mechanics, in engineering and in every walk of life and channel of industry for unexpected events to happen. Indeed, our lives are made up of unexpected events to their last, but it is not so with transformers, which are very rarely subjected to any disturbance to mar the usual serenity of their existence.

What happens when a transformer burns out? To begin with, heat is always developed by a transformer when it is in action, and this heat is taken up by the oil and delivered to the surface of the transformer case, or to water pipes within the oil chamber of the case, or otherwise, and so dissipated. At times when the transformer is working to its full capacity the temperature of the oil may reach 40 degrees centigrade above that of the surrounding atmosphere. If, now, a short circuit, that is, trouble of a very serious nature, develops within the transformer, and by raising the temperature of the oil to the boiling point. If the burn-out and arching occurs with explosive violence, then the oil will be blown out of the case and scattered about the premises unless provision is made to forestall such occurrence. The oil itself will not burn under ordinary conditions as to temperature and confinement, but when at the boiling point and scattered in all directions in this heated state it is not going to be impressed into service as the perfect substitute of a chemical engine. Fortunately, though, it is not one transformer in a thousand of those in use which burns out, especially if they be of the oil-filled variety, but when they do go there is, as the vernacular forcibly expresses it, "something doing."

The use of oil-filled transformers should not be regarded as a not unmixed evil, for whatever be the view point the tendencies exerted by the oil are far more for good than for evil. The hazard of the modern power house has been so reduced of late years that the hazard of the transformer is great only in comparison with it alone. As to present practices in transformer manufacture, I recognize but one weakness which I would eliminate in order to reduce their fire hazard, and that is the use of sheet iron casings, which, in the event of fire or particular station trouble, are easily broken or torn or punctured so as to release the oil and allow it to run out. Transformer casings should be of the most substantial and durable kind. They should, in the larger units, be erected on substantial foundations of concrete or other material of similar durability, and their oil-cooling connections should be so installed as to be free from liability to breakage or interruption even under such severe conditions as are imposed by fire. The reason for aspiring to this attainment is that as while it is the intent of the

*Abstract of a paper read before the annual convention of the Fire Underwriters Association of the Pacific, San Francisco, February 20–21, 1902.

oil, among other things, to carry away and dissipate the heat of the transformer coils through the medium of the water circulating pipes within the oil, the principal of cooling works both ways, inasmuch as it will dissipate external as well as internal heat. In fact instances have occurred where transformers have passed through fires without injury to their internal features by reason of the use of oil cooled by water circulation.

The real hazard of the transformer is that due to the storage of a very high grade oil under conditions wherein its temperature may rise to say a maximum of 40 degrees centigrade above that of the surrounding atmosphere, and where in rare instances a possibility of the scattering of the oil and its ignition from the cause which scatters it exists. As such the elimination of the hazard would be best accomplished by the confinement of transformers in separate fire-proof buildings, but whether it is always necessary to resort to this final expedient is a matter of grave doubt.

## WILLIAM STANLEY.

Mr. William Stanley, the central figure of the American Institute of Electrical Engineers convention recently in session at Great Barrington, Mass., is the man whose achievements gave start to the electrical progress in the Berkshires, which has made that section of Massachusetts famous the world over as the center of development of things electrical.

It was in the town of Great Barrington that William Stanley demonstrated to the world the commercial feasibility of the alternating current system, thus providing the means by which electricity could be served through comparatively small conductors over considerable distances. Today the great transmission feats of California, of which so much has been heard, where electric power is profitably conveyed over a stupendous distance of 220 miles, are the direct results of Mr. Stanley's successfully solving the problem at Great Barrington in 1885. Practically throughout the entire equipment Stanley apparatus is used on the world's longest transmission lines. Not only are these stupendous feats made possible by the alternating current system, but throughout the whole world electric light and power systems are in vogue supplying two-thirds of all current used which are also the direct evolutions of Mr. Stanley's work.

It was in the spring of 1885 that Mr. Stanley was taken ill and removed from Pittsburg to Great Barrington for his health. When he was able to be about he hired a disused rubber mill located some distance from the center of the town and engaged several assistants to construct the apparatus necessary to demonstrate the system which he had conceived. This work resulted in the building of the plant known to electrical engineers the world over as the Great Barrington plant, by which alternating current at 500 volts pressure was generated and led to the town proper, where transformers were connected and installed for the purpose of lighting part of the business section. The successful operation of this plant was undeniable proof that the means had been found by which electricity could be served over and throughout a large area commercially. It was a year or so prior to Mr. Stanley's building the Great Barrington plant that he made the acquaintance of Mr. Geo. Westinghouse, who was at that time desirous of getting into the electric lighting field. This acquaintance resulted in the formation of a company which has since become the Westinghouse Electric and Manufacturing Company. In the winter of 1890 and 1891, Mr. Stanley organized a company at Pittsfield, Mass., the Stanley Electric Manufacturing Company, for the purpose of making electric apparatus, and the first work that this company attempted was the production of a new type of transformer, which embodied several important improvements over the type then in vogue. At this time there were no alternating current motors, and as there was a great demand for such motors from the electric light stations of the company, Mr. Stanley, with his associates, Mr. John F. Kelly and Mr. C. C. Chesney, undertook the production of a self-starting motor that would give the alternating current system the same advantages that were possessed by the continuous current system when operating continuous current motors. This they accomplished, and the first successful Stanley motors were completed about the early summer of 1892. As the operation of these motors required that the generators which would furnish them with current should provide at least two alternating currents, differing in phase, and as the introduction of the motors was limited by the lack of necessary generators, the Stanley Electric Manufacturing Company proceeded to enlarge its capital and add to its equipment the necessary appliances for the manufacture of alternating current multiphase generators. The machine well known to the electrical men as the Inductor Type was the result of this move. There is now no more efficient piece of electrical apparatus than the Stanley type of electrical generator. In 1894 the Stanley Electric Manufacturing Company installed a multiphase transmission system at Housatonic, Mass., for the purpose of carrying the power developed by water fall between Glen Dale and Housatonic to the Monument Mill Company of that village. This plant operated at 2000 volts and was probably the first commercial installation of the transmission of electricity and its use as power in this country. This plant was followed by the introduction of electricity by many other plants in various portions of this country and in Canada, where many thousand horsepower are being transmitted by the Stanley apparatus. Among these plants are those already mentioned in California.

Mr. Stanley is a native of Brooklyn, N. Y., where he was born December 2, 1858. His electrical work begun with his acquaintance with Mr. Hiram (now Sir Hiram) Maxim, which he formed in 1877, when Mr. Maxim was chief electrician of the United States Electric Lighting Company of New York. Mr. Maxim at that time was one of the foremost inventors in electrical engineering work, and with him Mr. Stanley laid the foundation of his career. After serving a short apprenticeship with Mr. Maxim he was promoted to the position of first assistant, and in that capacity had charge of developing such new work as the company undertook. When Mr. Maxim left the United States to go to the Paris Exposition in 1891, Mr. Stanley resigned from the United States Electric Light Company and was engaged as assistant to Mr. Edward Weston, of the Weston Electric Light Company of Newark, N. J. Later, in 1882, while with the Swan Electric Light Company, of Boston, Mr. Stanley invented and perfected the methods of exhaustion for the incandescent lamp which are now largely used throughout the world, and which helped to make the incandescent lamp the success it is. Prior to the Roebling interests absorbing the Stanley Electric Manufacturing Company, Mr. Stanley organized a company in Great Barrington, the Stanley Instrument Company, for the manufacture of a new and decidedly novel wattmeter. The guidance of this concern's interest is his present vocation, and it may be added that new apparatus of great novelty in electrical engineering is now in course of commercial production at the works of the Stanley Instrument Company at Great Barrington.

## ELECTRIC LIGHTING IN MOROCCO.

There is but one electric lighting plant in Morocco, namely, at Tangiers. It is owned by the Campania Transatlantic, the local agent being Mr. A. Ortenbach. Owing to the increased cost of coal and increased working expenses, the rates for current have recently been advanced. The present rates are 1.20 pesetas per kilowatt-hour by meter, or 9.60 pesetas per month for a 16-candlepower lamp and 6.60 pesetas per month for a 10-candlepower lamp. The par value of the peseta is 20 cents. Street incandeslamps, including renewals, cost 7 pesetas per month. The plant stops at 10 P. M.

The Redlands Electric Light and Power Company, which supplies light and power to Redlands and Riverside, Cal., is building a third electric generating plant in Bear Valley. It will be completed by October.

## PERSONAL.

AN old friend under a new name is found in the Bay City Engineering and Supply Company, of San Francisco, which has succeeded not only to the business of J. C. Winans, but also to that of the Bay City Manufacturing and Rubber Company. The new corporation is located at 322 Howard Street San Francisco, and its executive officers are H. K. Moulthrop, C. C. Elsasser, H. E. Leland and A. Ingalsbe, to each of whom some personal reference should be made.

H. K. MOULTHROP.

Mr. H. K. Moulthrop was called to the presidency and general management of the Bay City Engineering and Supply Company immediately upon its organization, and his experience has particularly fitted him for the dual position which he holds. Mr. Moulthrop is a native son of California, having been born in San Francisco in 1862. His apprenticeship to the machinist trade was served at the old Miners' Foundry, during which time he was one of those who assisted Professor A. Van der Naillen in the design and building of the historic "grindstone frame" which gave so much to the reputation of the Miners' Foundry at that time. His apprenticeship served, Mr. Moulthrop accepted employment with the Presidio and Ferries Railway Company, more generally known as the Union Street Cable Line of San Francisco, as chief engineer, and he held this position from 1884 to 1891, when he resigned in order that he might enter the service of the Edison Light and Power Company, since merged into the San Francisco Gas and Electric Company. One year later Mr. Moulthrop was offered and accepted the position of superintendent of the department of maintenance of the San Francisco Land and Improvement Company (now the Western Meat Company), but some eight or more years ago he resigned that position in order to assume the management of the engineering supply business of J. C. Winans. In addition to its duties, Mr. Moulthrop was also connected in an unofficial capacity with the purchasing department of the Oakland Transit Company (consolidated). Hence it is that when the Bay City Engineering and Supply Company was incorporated early in the present summer, Mr. Moulthrop's position and experience naturally called him to the position of trust and responsibility which he holds in the new concern.

C. C. ELSASSER.

Mr. Charles C. Elsasser, who holds the position of superintending engineer of the Bay City Engineering and Supply Company, was born in Baltimore, Md., on June 1, 1867, but while still an infant he was brought to California by his parents, arriving here in the spring of 1868. His education was obtained in the public schools of San Francisco, from which he graduated in the grammar grade in 1881. Early in the following year he was apprenticed as a machinist in one of the largest shops of this city, but while serving this apprenticeship he greatly furthered his education by attending evening schools. After having served his four years' apprenticeship he became an oiler on the Pacific Mail Steamship Company's steamship City of New York. He remained in the employ of the Pacific Mail Company for five years, at the end of which ttme he assumed the duties of the second engineership of the steamship San Juan. Feeling that his experience would ripen more rapidly if engaged in stationary engineering work, he quit his position on the San Juan in 1891 and entered the employ of the California Electric Light Company as engineer in Station B, which was at that time undoubtedly the largest steam electric light station west of the Rockies. Mr. Elsasser continued in the employ of the California Electric Light Company and the corporations which succeeded it, viz., the Edison Light and Power Company and the San Francisco Gas and Electric Company, until early in the summer of the present year, when he resigned to enter the service of the Bay City Engineering and Supply Company. That he is thoroughly well fitted for the important duties which confront him in his new position is indisputable, and it is but a slight mark of the high esteem in which he is held by his co-workers in the steam engineering profession to note that the Eighteenth Annual Convention of the National Association of Stationary Engineers, held at St. Louis in September, 1899, elected Mr. Elsasser to the office of national conductor of the organization.

H. E. LELAND.

Mr. Harry E. Leland, who has charge of the various local agencies of the Bay City Eegineering aud Supply Company as far East as Denver, is also a native son, having been born in Watsonville in 1867. When twenty years of age, and after having finished schooling, he obtained employment in the Sixteenth Street shops of the Southern Pacific Company, San Francisco, and he remained in the employ of the railroad, working in the shops and running on the road, for five years, when he moved to San Jose that he might accept the more important position of running the refrigerating machinery in the Fredricksburg Brewery of the San Francisco Breweries (limited). Further advance being offered, he left the employ of the brewery and became first assistant engineer of the Agnews State Hospital for the Insane, where he remained for six years, leaving it to accept the position of chief engineer of the Santa Clara Municipal Water and Light Works. From Santa Clara Mr. Leland came to San Francisco to enter the employ of the Bay City Manufacturing and Rubber Company in the capacity of sales agent. His present position as manager of sales in the new organization is simply along the line of deserved promotion and development.

Mr. A. Ingalsbe, who completes the quartette of principals of the Bay City Engineering and Supply Company, and a half tone of whose photograph is here given, is secretary of the corporation, and his genial presence gives assurance that patrons who enter the office will be assured of a welcome. More than this, the entire personnel of the company is such that even without the stimulus of the excellent business to which the concern succeeded, its success along the lines of industry to which it aspires is more than assured, for its personal and business qualifications are eminently of the best.

A. INGALSBE.

The company is prepared to contract for the erection of steam plants. In the shops may be seen the process of manufacture of steam and water packings. In another department the visitor, always welcome, may see under construction various steam appliances, such as steam traps, steam separators, damper regulators, etc.

ROBERT BRUCE FLATHER, who is one of the most recent acquisitions to the electrical fraternity of the Golden State, was born in Bridgeport, Conn., in 1871, but the earliest years of his life were spent in England and Scotland, although the return of his parents to Bridgeport while he was still hardly more than a child enabled him to obtain an education in the public schools of his native town. When seventeen years old he went to work in the incandescent electric light department of the United States Electric Lighting Company at Newark, N. J., which was then turning out the Weston lamp, which at that time took rank with the Edison, Swan, Lane-Fox and Sawyer-Man lamps. Later on, after young Flather had proved his usefulness in the Weston lamp factory and had worked his way into its laboratory, he worked side by side with two men whose names are well known in the electrical engineering world, namely, Professor R. A. Fessenden and Theo. E. Theberath, constructing engineer for the Valley Counties Power Company of the Bay Counties Power Company.

After an experience of three years in the Weston lamp factory, Mr. Flather was offered and accepted the position of foreman of the carbon department of the Sawyer-Man Electric Company, of New York, where he remained for a year or more, resigning only to complete his education. This he did by entering Purdue University, from which he graduated in 1895 in the class of mechanical engineering. Immediately thereafter Mr. Flather entered the employ of the Westinghouse Electric and Manufacturing Company, at East Pittsburg, as foreman of its instrument department, but his earlier associations proved more attractive than the later ones, and he soon re entered the employ of the Sawyer-Man Electric Company as lamp expert and foreman of its works at Allegheny, Pa.

ROBERT BRUCE FLATHER.

Something over a year ago, however, Mr. Flather determined to come out West to "grow up with the country," and this determination resulted in his being offered and accepting the position of superintendent of the Colorado Lamp Company's factory at Denver, which position he held until the spring of the present year, when he accepted the superintendency of the lamp factory of the California Incandescent Lamp Company, of San Francisco. This position Mr. Flather now holds to the eminent satisfaction of his employers, as well as to his own contentment.

Mr. Flather is a member of Phi Delta Theta fraternity of Purdue University and of Tau Beta Pi, which is an engineering society founded in Lehigh University. His brother, John J. Flather, is professor of mechanical engineering of the University of Minnesota.

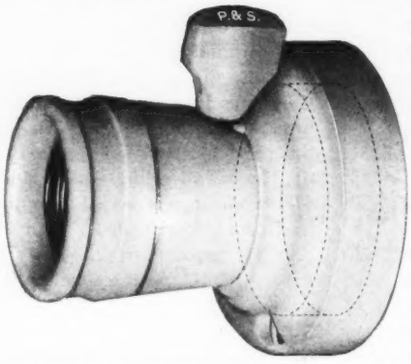
Mr. GEORGE GARY LYON, late secretary and treasurer of the Snoqualmie Falls Power Company, died in Seattle, Wash., on July 17th last, in the sixty-first year of his age. The high character, ability and fidelity of their late lamented and esteemed associate is marked by the directors of the company in an exquisite "In Memoriam" tablet which they have issued.

## "CASSIER'S" MINING NUMBER.

Another of the superlative special issues of *Cassier's Magazine* has appeared and its excellence is not to be gainsaid. It is the "Mining and Metallurgical Number," and of among its contributors are the names of two San Franciscans: Edward A. Rix discusses "Compressed Air in Mining" and A. P. Brayton, president of the Pelton Water Wheel Company, writes upon "Water Power in Mining," with especial reference to the development and application of tangential water wheels in the various forms of mining service.

## THE NEW P. & S. CONCEALED WALL SOCKET.

THE accompanying cut shows a new article which has just been put on the market by Pass & Seymour (incorporated), Solvay, N. Y. There has been an increasing demand for a concealed wall socket that would meet the requirements on which the price would not be prohibitive, and in introducing this socket the manufacturers have every reason to congratulate themselves that they have been so successful. The socket is made of the well known P. & S. Porcelain, and is a combination of strength, durability and efficiency. It is made with a hollow back, two inches across and one-half inch deep, thus making it a very useful device for covering up the ends of tubes, circular loom, etc., even though they protrude somewhat from the wall. In fact, by its use a neat looking job can be made of what would otherwise be considered a bungling affair. This socket, as well as their other well known pendant fixture and regular wall sockets, are approved for 250 volts, and appear in the national list of approved fittings. Special prices have just been issued on all P. & S. porcelain, which are gladly furnished on application.




The Pacific Coast offices and warehouse are located in the Mills Building, San Francisco, where a full and complete line of P. & S. specialties are carried by The Chas. F. Sloane Company.

## THE WESTINGHOUSE TYPE N TRANSFORMER.

AS the Westinghouse Company was the first to introduce the practice of winding for two primary and two secondary voltages, it is not surprising that this company has taken another step forward in the same direction by bringing out a transformer provided with additional voltages. The new transformer (Type N) is not intended to replace the company's well known O. D. Transformer, but rather to fill the demand for a reliable transformer, which, provided with additional ratios of transformation, has a greatly extended range of voltage. The shell type of construction used in Westinghouse O. D. Transformers and on the company's large high voltage transformer is up to 100,000 volts and 2750 kilowatts capacity.

The primary winding of the Type N Transformer is divided into equal parts, which may be connected in series or in multiple. The secondary winding is divided into four equal parts, which may be connected in series, series multiple or multiple. The primaries of all transformers are wound nominally for 1000 and 2000 volts. Transformers from one-half to twenty-five kilowatts, inclusive, are wound for nominal secondary voltages of 50, 100 and 200 ("Class 200"), and those from two to fifty kilowatts, inclusive, for voltages of 100, 200 and 400 ("Class 400"). The secondary voltages in each class of transformers can be varied to suit either the varying line voltages of an extensive transmission system or to give special voltages from standard circuits. All transformers are arranged for three-wire secondary distribution, and the secondary coils cross-connected to give equal voltages on both circuits, even with large unbalanced loads.

The Bay Counties Power Company is about to build a large dam near Nimshew, Cal., which will be the head of a pipe line to the new power plant to be built on Butte Creek. The dam will be forty feet high and will form a reservoir from which pipe lines will extend to the Butte Creek site, where a vertical fall of 1600 feet will be had. The plant at this point will develop 1200 horsepower.

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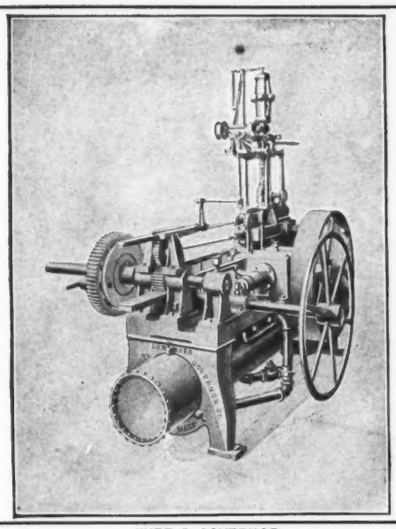

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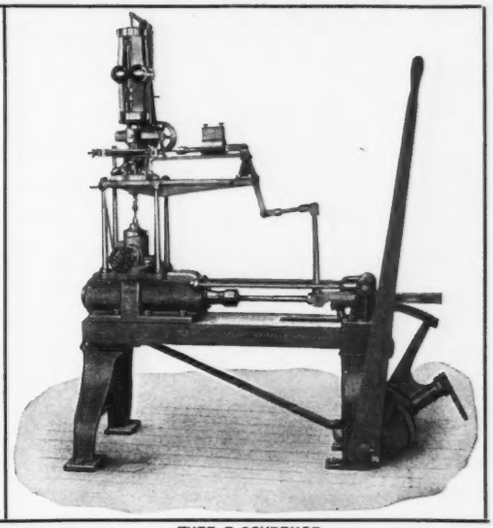

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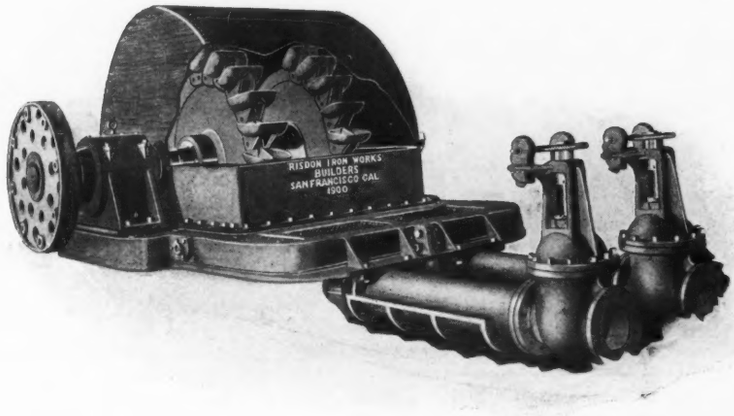


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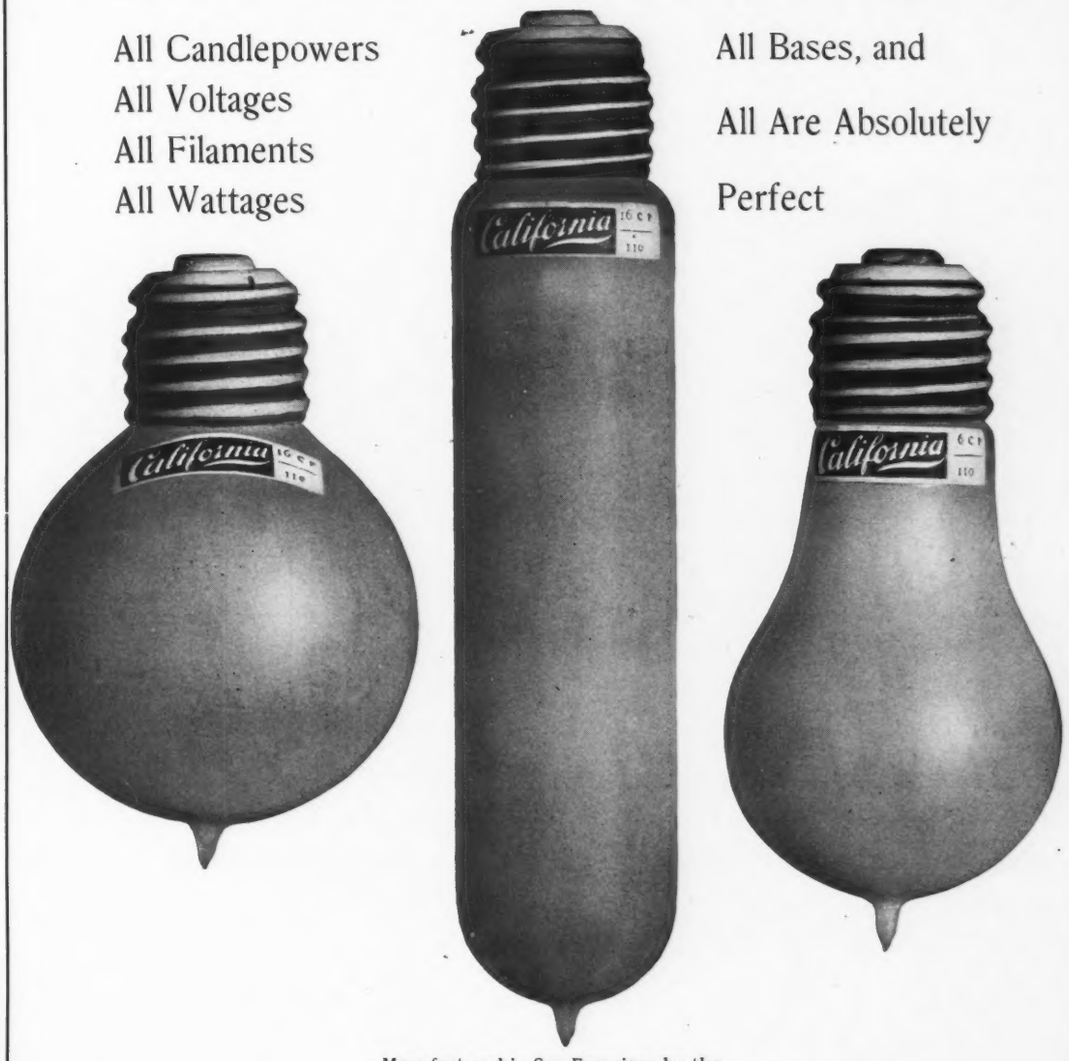


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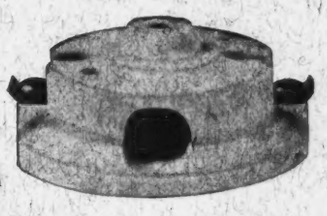

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**Excerpts from affidavit of Mr. Charles A. Terry, secretary of the Westinghouse Electric and Manufacturing Company, in their most recent suit against the Stanley Electric Manufacturing Company for alleged infringement of patents 381,968 and 382,280.**

[Motion for an injunction has been denied.]

" * * * the defendants have been bidding against us on plants of the largest size, and have succeeded in securing an increasing number of orders recently by heavy cuts in prices, and by guaranteeing their purchasers against liability for infringement * * * "

" * * * I am of the opinion that it would be in many cases practically impossible for us to meet such competition without serious damage to ourselves, owing to the fact that unlicensed competitors not having to pay the cost of maintaining expensive patents, or to reckon the interest on the money already expended on account of such patents, can set a price which it would be inequitable for us to have to meet * * * "

Please contemplate:

(*a*) The unreasonableness of the purchaser paying for the patents and the patent litigation of the Westinghouse Electric and Manufacturing Company.

(*b*) Where prices would go without the competition which the Stanley Electric Manufacturing Company helps to maintain.

(*c*) That we are in the business to stay and have the necessary shops and capital to handle advantageously any undertaking.

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